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TREES

A HANDBOOK OF FOREST-BOTANY FOR THE WOODLANDS AND THE LABORATORY

By

H. MARSHALL WARD, Sc.D., F.R.S.,

Fellow of Sidney Sussex, and Honorary Fellow of Christ's College, Cambridge, and Professor of Botany in the University.

Author of *The Oak; Timber and some of its Diseases; Grasses; Disease in Plants; &c.*

VOLUME I. BUDS AND TWIGS.

WITH ILLUSTRATIONS

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PREFACE.

THE purpose of the series of volumes of which this is the first, is to provide Students of Forest-Botany with a guide to the study of trees and shrubs from the point of view of the outdoor naturalist. At the same time I hope to interest them in certain methods of laboratory work, which help us to amplify the results of field-studies by the examination of the objects observed in their native habitats, somewhat more closely under the lens or microscope.

Somewhat gloomy views have occasionally been expressed by botanists who deplore the neglect of natural history studies in the open, the now common use of the microscope and of laboratory methods having, in their opinion, exercised a powerful fascination on the study of plants detrimental to outdoor work. Considerable experience has convinced me that the neglect of the older methods of observation of the living plant, which rendered the study of Botany so exhilarating to the naturalist of pre-laboratory days, is to a large extent our own fault. The text-books of to-day, excellent as they are in most respects, are apt to lack that peculiar kind of stimulus, so necessary for young students, which

drives the reader to observe and think for himself, and not through the eyes—or worse still the words—of others.

No one has more respect for the Floras of the Empire which created Floras than I have ; and no one could claim to appreciate more fully the invaluable laboratory handbooks on the Morphology and Histology of Plants, which we first translated from the German and then improved upon and made after our own methods, than I do. But the scope of such works is restricted in each case to a particular side of the subject, though to a side which the real student of Botany should not neglect.

Few would deny that the proper use of a Flora is in the field ; but we all know that the best Floras are too bulky for such work, and that the tendency is to collect in the field and to use the Flora in the Herbarium, because the few field-floras sufficiently compact to carry about have too much of the character of note-books to be used with effect by any but practised experts. On the other hand, the Laboratory Handbook finds its proper scope indoors, where alone the microscope and its adjuncts can be employed, and such books are too much occupied with general views of the enormous area of knowledge in which they are the legitimate guides, to find time or space for the details of plant-life in the open.

Nor do the new departures attempted by the modern studies of the biology of the living plant, whether concerned with types of structure, with geographical distribution, with the problems of œcology, or with other physiological aspects of the organism, meet the requirements of the case.

The object I have in view should, I think, be antecedent to that of all such studies, namely, to encourage an acquaintance at first hand with the plant in its own home: not merely a knowledge of the characters of the flowers, fruits, &c. which have been chosen by systematists as useful in accepted schemes of classification, but also of those features of buds, twigs, leaves, seeds, seedlings and so forth which are necessarily absent from the typical Flora, although they are employed in special Floras and handbooks used by experts.

Of course, I am not so *naïf* as to suppose that all such information could be crowded into a work of the kind here contemplated, or that the object in view—to attract the student to the plant itself—would be advanced if such were accomplished. What is here aimed at is rather to show the kind of work that can be done in this way.

It may be objected—and such objection is characteristic—that such a plan involves too much detail. My reply is that there is no such thing as too much detail in the study of Nature: true, the student may be led into *too many details*, into trying to fix in his mind too many facts about too many organisms, but that is a very different thing from learning to observe thoroughly the many and various peculiarities of structure and adaptation of a group of organisms.

I have attempted elsewhere to show how such a course of study may be pursued in connection with a particular natural order of plants, allied in the strictly genealogical sense of the systematists, viz. the Grasses. Here the same methods are applied to a group of plants of very

various blood-relationship, but commonly classed together by the people on the basis of certain biological features they have in common, viz. in being woody and all that that implies. In both cases the further limitation is imposed that we deal with the plants of our own country, or such as are commonly planted here, and this restriction is the less a disadvantage, because our native and introduced species happen to be very excellent representatives of the group selected.

But, in addition to the hope that such studies may encourage closer work in the field, and convince students that Field-Botany is not confined to a few weeks of our fleeting seasons, I also hope to show that they are useful to the expert. Rarely have I experienced a greater surprise, or enjoyed days of field-work more, than during a fortunate visit many years ago to one of the greatest Forest-Botanists ever known to Europe : he could recognise practically every species of tree, shrub, or bush we met with, from the smallest piece of twig with one or two internodes on it, or from a mere fragment of its wood or bark or leaf, and if anyone is inclined to regard such knowledge as barren, let him look into the work that Robert Hartig accomplished during his lifetime.

The purpose of this work, then, is several sided. It appeals to the amateur who wishes to know something of the study of trees and shrubs—and is for that reason expressed in language devoid of unnecessary technicalities —and so comprises an introduction to Nature-Study in what I hold to be the true sense of that much-abused term ; it also comprises an introduction to the methods

of systematic botany and morphology, and to the expert study of Forest-Botany. Nor shall I avoid sections on Histology and Physiology when they come legitimately within the scope of the scheme, so that the latter may be shortly expressed as an attempt to teach the fundamental principles of Botany by means of examples selected from trees and other woody plants.

Succeeding volumes are designed to deal with the Leaves, Inflorescence and Flowers, Fruits and Seeds, Seedlings, and the Habit and Conformation of the Tree as a whole, in a similar way, in each case with diagnostic tables at the end to be devised for use in the field.

The illustrations of twigs in the present volume are to so large an extent due to the skilful drawing of Miss Dawson, of the County School, Cambridge, that I wish to express my special thanks to her for the trouble she has taken: her drawings are marked (D). In addition to these, other drawings have been obtained, by the courtesy of the various publishing firms concerned, and are marked as follows:—(F) Figuier; (E and P) Engler and Prantl; (Wo) Wossidlo; (Wi) Willkomm; (Sc) Schwartz; (Ha) R. Hartig; (He) Henry, *Knospenbilder* 1846; (K) Kerner; (V) Veitch; (Sa) Sachs; (Ei) Eichler. Other illustrations are from my own drawings.

Thanks are also due to my wife for preparing the index and reading through the proofs.

H. M. W.

July 1904.

CONTENTS.

PART I. GENERAL.

CHAPTER		PAGE
I.	The Shoot-System	3
II.	The Bud	9
III.	The Bud (*continued*)	23
IV.	Position and Arrangement of Buds	30
V.	Position and Arrangement of Buds (*continued*)	36
VI.	Analysis of Buds	41
VII.	The Bud-Scales	49
VIII.	Arrangement of Leaves in the Bud	58
IX.	The Opening of the Bud and Extension of the Shoot	64
X.	Different Kinds of Shoots	76
XI.	Tegumentary System—Epidermis	81
XII.	Tegumentary System (*continued*) Cork—Periderm	94
XIII.	Leaf-Casting and the Formation of Leaf-Scars	100
XIV.	Twigs	107
XV.	Leaf-Scars and Lenticels	113
XVI.	Accessory Characters of Twigs	124

PART II. SPECIAL.

PAGE

I. Evergreen Plants 133

II. Non-evergreen Plants 150

A. Buds and Leaf-Scars opposite 150

B. Buds &c. alternate 174

(1) Buds distichous 174

(2) Buds spirally arranged 189

(*a*) Twigs armed with spines &c. . . 189

(*b*) Twigs unarmed 204

Bibliography 259

Index 261

PART I.

GENERAL.

CHAPTER I.

THE SHOOT-SYSTEM.

Root-system and shoot-system compared and contrasted—Definitions—Segmentation of shoot—nodes and internodes—stem, branch, twigs, leaves and other organs—The embryo plant—its discernible parts—cotyledons, plumule, &c.—The plumule the primary bud.

It is, of course, merely stating the obvious to say that all our ordinary trees and shrubs consist of two principal parts, the stem-parts rising into the air and light and the root-parts descending into the dark soil: nevertheless, it adds to the definiteness and accuracy of our conceptions if we not only emphasize this statement, but also examine it somewhat more closely. It must be noted that we are here speaking of our ordinary common types of trees and shrubs, and with that qualification we may agree to term the underground portions, as a whole, the Root-system, while the parts above-ground, no matter how complex they may eventually become, as stems, branches, leaves, flowers and fruit, &c., appear in succession, may be designated by the comprehensive term Shoot-system.

But experience soon shows that cases occur where root-system and shoot-system, though sharply marked off one from the other, are not sufficiently defined by the above

simple characteristics. For instance the Mistletoe sends its roots into the tissues of poplars and other trees, and most of the roots of the Ivy are affixed to the bark of a tree, or to the wall up which it climbs: in these cases it would be absurd to define the root-system as that part of the plant which descends into the soil; and, not to multiply examples, such considerations have forced botanists to be somewhat more precise in other points of the definition.

Without going further than is justified by the aims of a work like the present, it may suffice to point out that all the plants we have to deal with agree in the following particulars.

True roots never bear leaves or flowers or fruits; whereas the most characteristic features of the shoot-system are furnished by these particular appendages. And even in cases, not exemplified by any of the trees or shrubs here to be considered, where roots branch on the aërial parts of other plants and even turn green and flatten out, and in other ways behave unlike the ordinary roots of ordinary plants, they do not habitually produce branches of unlike nature, bearing green leaves, buds, tendrils, flowers and fruits, as does the shoot-system.

In the case of any ordinary shrub or tree, therefore, all that we are in the habit of seeing above the ground is the shoot-system, the root-system being underground, and, apart from difficult cases to be specially examined and discussed, the difference is sufficiently marked by this: we can, however, include the various classes of shoot-system still more completely by adding to the definition that the shoot-system bears the leaves, the flowers and the reproductive organs proper.

In the case of our more familiar plants it is obvious that we may add yet other characters to aid in defining

the shoot-system. The green colour of the foliage of our common trees and shrubs is strongly in contrast with the non-green of the roots, and this green colour is especially correlated with the aërial position of the shoot, an organ normally adapted to life in the air and the light.

Most elongated shoots exhibit definite segmentation into joints or *nodes*, where the leaves are inserted, and *internodes*, the stretches of stem between, and this jointing is frequently accentuated by swellings at the leaf-insertions, e.g. the Vine.

The typical shoot-system, as exemplified by an Oak or Beech, a Blackthorn, Holly or Barberry bush, exhibits degrees of subdivision into outgrowths of various kinds which necessitate such terms as stem, branches, twigs, leaves, spines or prickles, flowers, and others, but the student should note that the idea of the shoot-system, as opposed to the root-system, by no means depends essentially on the presence or absence of distinct internodes, or segments, or any particular form of outgrowth.

It is a fundamental peculiarity extending to all the plants with which we are here concerned, that each commences its external life as a seedling, developed from a seed: the fact that numerous plants exist which never form seeds does not here concern us at all, and we may dismiss them altogether from consideration. Even the tallest tree—and we may note that there are trees in existence over four hundred feet in height and over a thousand years of age—was once a seedling, consisting essentially of four discernible parts, as shown in Fig. 1. There is first the minute thread-like primary root, or *Radicle*, the first outgrowth of the root-system, which, in the case selected, descends into the earth to afford the first support to the plant, and to absorb the first supplies of water, with dissolved salts, from the soil. Then, secondly,

there is the erect *Stem*, ascending into the light and air, and bearing, thirdly, the first leaves which the baby plant possesses, and which are peculiar in many respects, but

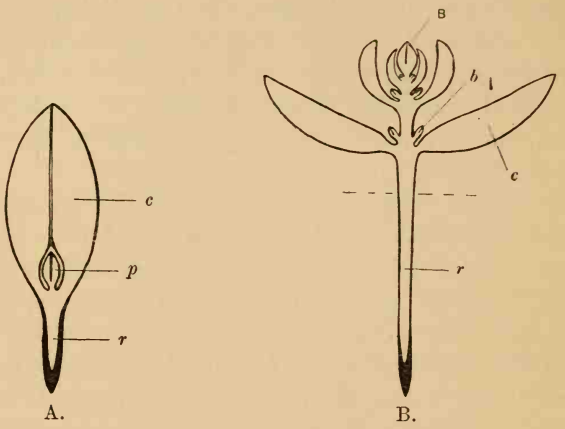


Fig. 1. A. An embryo plantlet dissected from the seed. *r* radicle, or primary root; *c* cotyledons; *p* plumule. B. The same after further growth into a seedling. *r* and *c* as before; *B* the terminal bud; *b* buds in axil of cotyledons. All between *b* and *B* is the young shoot developed from the plumule. The first internode above *b* is termed the epicotyl.

especially in that they accompanied the seedling while it was still wrapped up and tucked away inside the seed. They are consequently termed seed-leaves, or, since a more general term applicable to all cases has advantages, *Cotyledons*. Between the cotyledons, and tucked up closely in their embrace during the early stages of its life in the seed, there appears a fourth structure, the primary bud of the seed: this bud consists of the end of the up-growing stem, closely invested by a number of still minute and closely packed organs, which will eventually grow out into leaves. This primary bud of the seedling was termed

by the earlier botanists the *Plumule*, and the somewhat fanciful name has been preserved.

Here, then, we have sketched out as it were the architecture of the young shoot-system. This grows out by the elongation of its internodes, and the expansion of its leaves, and soon reaches a stage comparable to that shown in Fig. 2 A. At the end of its growth for the season,

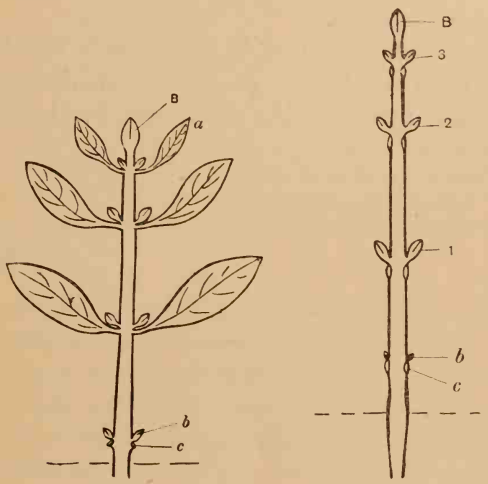


Fig. 2. A. Shoot of seedling such as that in Fig. 1, at end of first year. *a* last leaves expanded; *B* terminal bud; *b* buds in axils of cotyledons; *c* scars of fallen cotyledons. B. Shoot of seedling such as that in A, after it has shed its leaves, and passed into the stage of winter rest. *c* scars of the fallen cotyledons, with their axillary buds *b*; 1—3 lateral buds in the axils of successive leaves which have fallen and left scars. *B* terminal bud.

the leaves fall, and the shoot becomes a twig, as in Fig. 2 B, and rests through the winter. In the ensuing spring growth is renewed, and in process of time the terminal

and other buds put out new shoots, which will in their turn elongate and enlarge, add more leaves, buds, and branches, and eventually form flowers and fruits, &c.; but however large and complex it may become, and however long it may live, the huge shoot-system of the tallest Pine or of the oldest Oak was once no more than a bud (plumule) just emerging from between the cotyledons, and terminating the seedling stem of a minute plantlet such as has been described.

Since the shoot-system is thus merely the developed and differentiated plumule, or primary bud of the seedling, we commence by examining the typical bud in detail.

CHAPTER II.

THE BUD.

General definition—Simple Bud of Cabbage, Lettuce, &c.—General structure—Axis and leaves—Section of bud—Comparison with plumule—Winter buds—Bud-scales—Dissection of bud of Horse-chestnut—Transition of scales to leaves—Compound bud of Pine—Bud of Spruce Fir—Bud of Elm—Plan-diagram of bud—Nature of bud-scales.

A BUD is simply the end of a shoot-axis in a young, and as yet short, or condensed, and undeveloped state, surrounded by a series of young leaves, also awaiting conditions which will bring about their growth and expansion. This is evident from examination of the primary bud, or plumule, of the seedling, which we have seen to be composed of the first young leaves (after the cotyledons) of the primary shoot, wrapped one over the other and enveloping the tip of the first shoot.

If we look closely at a few examples of buds, it is soon evident that differences in detail occur which distinguish them more or less obviously one from another; and even a casual observer notices that the buds of different plants do differ considerably.

One of the simplest examples we can select for dissection, owing to its large size, is a Lettuce, a Cabbage, or a Brussels Sprout, in the condition usually met with

when cut for the table; but it should be noticed that the following statements apply generally to any bud. On carefully removing the older leaves, beginning from the outside, we find them more or less tightly folded over one another, and over a point near the centre of the mass, which is found on examination to be the termination of the stem. The outermost leaves are attached lower down on this axis than the inner ones, and they are also larger than the latter: moreover they are more loosely wrapped over the inner leaves, and if the Lettuce or Cabbage has been cut rather low down, the most external leaves of all may be already expanded, or in process of expanding, and throwing themselves back and off from the central parts of the bud, as it were, so that their uppermost surface is no longer in contact with the more solid mass of young leaves inside. A little closer observation will show that the parts of the stem between the leaf-insertions—i.e. the places where leaves and axis join—of these outer older leaves are not only thicker than those higher up, but have also grown longer so as to drive these leaf-insertions further apart: in other words, distinct internodes can be seen here.

As we proceed with the dissection, however, the leaves will be found more and more closely packed one over the other, and smaller and smaller as we penetrate the interior or "heart" of the Cabbage: they also are curved inwards, and their concave surfaces are applied more and more closely to those internal to them; and, lastly, they are more and more delicate in texture, because they are younger and less matured.

As we continue to remove leaf after leaf, we at length arrive at the small delicate end of the stem, which was entirely arched over and closely covered up by the inner leaves; while the part of the axis which we have exposed

by the removal of its closely packed leaves, appears as a more or less conical or dome-shaped body on which the ruptured leaf-insertions stand out as sections of the base of the leaf, arranged in close spirals round the axis.

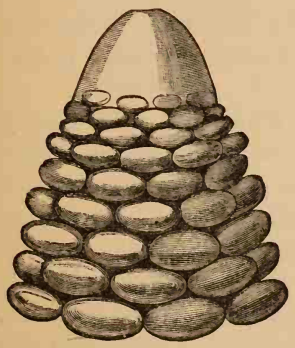


Fig. 3. Apex of shoot dissected from the bud and viewed from the side. Highly magnified, and showing the terminal dome of tissue with the spirally arranged and closely packed protuberances, each of which will grow out into a leaf (Sa).

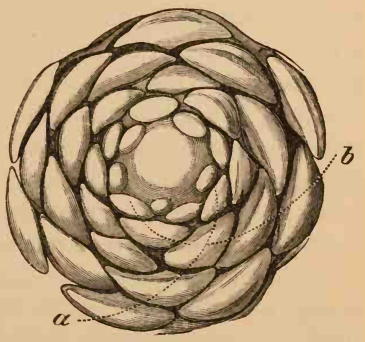


Fig. 4. Apex of shoot of Fir dissected from the bud and viewed from above. Highly magnified and showing the tip of the dome, with its lateral, spirally arranged and closely crowded leaf-incepts, as in Fig. 3. *a* and *b* lines indicating the spirals (Sa).

By means of a lens or microscope we can see that even when we have with some difficulty (owing to their delicate texture, small size and close packing) removed the youngest leaf we can recognise as such, there are still a number of tender knobs on the surface of the central stem-end: these are the inceptions, or beginnings, of leaves which are still so young as not to have acquired their flattened form, or any difference between leaf-stalk (petiole) and blade (lamina); see Figs. 3 and 4. Very often there are other outgrowths also in a similar young condition, apparent as tiny knobs, which are the beginnings

of new lateral buds in the angles between leaf and stem —the so-called leaf-axils—and which would subsequently have developed in their turn to buds with similar structure.

All these matters can be made clearer by cutting the Lettuce, Cabbage, Lilac bud, &c. accurately down the middle, so that the longitudinal section exactly halves the stem and its young leaves.

Such a longitudinal section shows still more clearly that the bud consists of a conical prolongation of the stem, from which, on all sides, the young leaves are given off as lateral outgrowths, and this in such a way that the youngest of the leaves arise at points nearer the true tip of the stem than does any older one. One difference which is soon obvious is that while in the Lettuce, Cabbage, &c. the leaves are arranged in spirals, in the Lilac and others they are opposite on the axis, as seen in Fig. 5.

If the bud is sufficiently advanced, moreover, we can see that the more developed leaves become successively removed further and further apart from the younger ones —and are therefore no longer to be reckoned as concerned in the bud proper—by the elongation of the internodes between them and the latter, the apex of the stem in the bud being therefore carried higher up into the air. At the same time these maturing leaves expand, partly by the flattening out of the hitherto incurved and concave upper surface, and partly by the enlargement of the latter and the elongation of the petiole, during the process of growth.

A careful examination of sections of the plumule or first bud of successively older germinating seeds will show the student that it is composed in exactly the same way of a series of overlapping young leaves, curved in over the true apex of the primary shoot, and so developed on the

latter that the outermost—i.e. those lowest on the stem —are the oldest and largest, and the innermost—i.e. uppermost—are the youngest; and that the gradual emergence of the primary shoot from between the cotyledons, and its elevation above the surface of the soil, where it expands leaf after leaf to the light and air, are due to the successive growth of the internodes between the leaf-insertions. First the internode (the epicotyl) between the insertions of the cotyledons and the bud elongates, and the plumule or primary bud is freed and elevated into the light and air: then the next internode elongates, and so on, the corresponding leaves becoming free and expanding in the order of their succession from oldest to youngest.

When these leaves are fully expanded, we shall generally find that they have buds in their axils: and it is from these axillary buds that the lateral branches will be developed in exactly the same manner by the elongation of their internodes, and since the structure of each lateral bud is essentially the same as that of the terminal bud already described—each, in fact, being the terminal bud to the branch into which it develops—there is no need to do more than indicate them, and to point out that it is especially in perennial plants, such as trees and shrubs, that these axillary buds are prominent, though they are commonly to be found even in the axils of the cotyledons, or first seed-leaves.

So far I have considered the simplest case of a bud, the leaves of which are all alike, or nearly so, and of the usual herbaceous texture characteristic of green leaves. But it is evident at a glance that in the buds of most of our forest trees and shrubs, which rest during the winter, the outermost coverings of the bud, the *bud-scales*, are very different in texture from the delicate young leaves inside; this is

owing to certain changes which ensue in the texture of the more external of the young leaves composing the

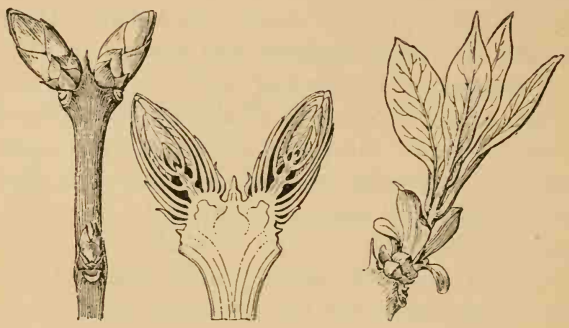


Fig. 5. Opening of the bud of the Lilac. That to the left shows the loosening of the bud-scales preparatory to expansion; then, the same in section, slightly magnified. That to the right shows the bud-scales reflexed and the leafy shoot elongating (Wo).

buds when the latter are first formed in the autumn, ready for the winter rest. These outermost leaves, or parts

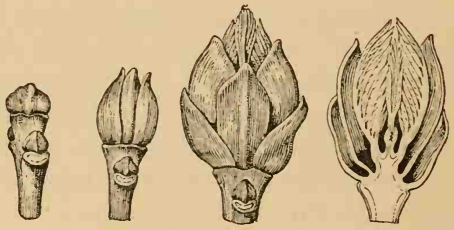


Fig. 6. Opening of the bud of the Ash. From left to right, the resting bud, then the bud-scales loosening, next the tips of the leaves protruding, and, lastly, the same in vertical section. The scars of the leaves between which the bud developed are seen at the base (Wo).

of leaves, become hard, tough, and scale-like, and thus better adapted to protect the delicate parts inside from

the effects of frost, rain, &c., and especially to prevent any excessive loss of water during periods when the air is dry, and particularly when winds are passing through the trees, since such loss of water at a time when the interior of the plant and the roots are not capable of replacing it would lead inevitably to the death of the delicate tissues of the terminal cone and its youngest leaves in the interior of the bud.

It must not be assumed, however, that a winter bud is necessarily covered with such scales. The naked, or scaleless buds of the Cabbage and Brussels Sprouts are quite able to withstand the winter, and, as we shall see, naked buds occur on trees and shrubs likewise, e.g. the Wayfaring Tree.

To illustrate the structure of a scaly bud, we may dissect the large terminal bud of a *Horse-chestnut* (Fig. 7). Proceeding as before, we remove first a succession of deep brown, hard, leathery, hood-like scales, usually viscid with a resinous secretion which glues them together: these bud-scales are arranged regularly in pairs at right angles, each pair partially covering the next inner pair. The most external pair of scales are smaller than the next

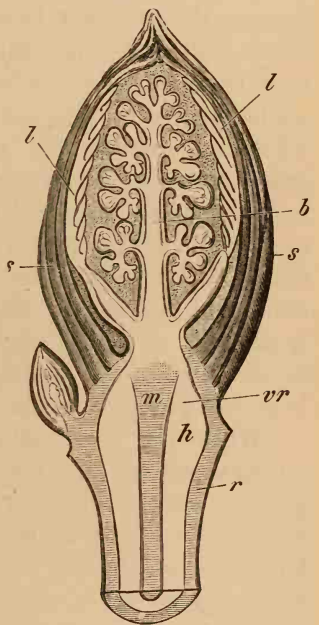


Fig. 7. Bud of Horse-chestnut in vertical section, slightly enlarged. *m* pith; *h* wood; and *r* cortex of the shoot-axis *vr* of the past season; *s* bud-scales; *l* leaves; *b* inflorescence in the bud-state (Sa).

inner pair, and these than the next, then come two or three pairs of maximum size, closing in the bud by their apices. Inside these scales we then come upon one or two pairs of similarly shaped, but green and herbaceous organs, often very viscid owing to the slimy secretion referred to above. These we hesitate to call scales, because they are not hard and brown, and we will provisionally term them intermediate leaves; while further in still we have what are undoubtedly young green leaves, closely folded up and very hairy. Occupying the apex of the axis, on which these scales, intermediate leaf-structures and leaves are inserted, is the tuft of organs marked *b* in the figure, and which is a branched group of flowers.

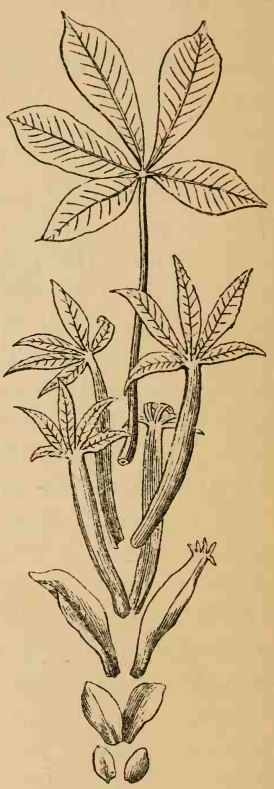


Fig. 8. Successive bud-scales and leaves from an opening bud of *Æsculus*, showing the transition from leaf-scales to fully developed leaves (G).

When the bud swells and bursts in spring, all mystery regarding the relations of the intermediate leaves to the true bud-scales on the one side, and to the leaves on the other, disappears, for it becomes clear that they are really intermediate between scales and leaves, and we pass gradually through a series starting on the outside—i.e. below—with true scales showing no vestige of leaf-blade or green herbaceous texture,

to scales which incline to be herbaceous above or even to bear traces of leaf-blades, to more and more perfect Horse-chestnut leaves as we ascend (Fig. 8).

The comparative series displayed also shows us that the bud-scales in the Horse-chestnut are morphologically leaf-bases, i.e. the bases of leaves which develop no upper parts or blades, and become hard and scaly as the buds form. This point is of some importance, since, as we shall see, bud-scales differ as to their nature in other ways.

A similar case to that of the Horse-chestnut is met

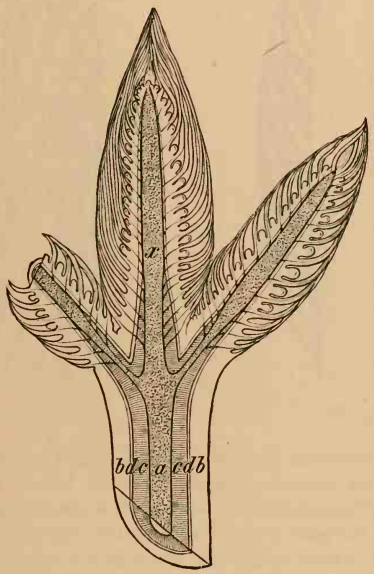


Fig. 9. Vertical section through buds of a Pine, *Pinus austriaca*. *a* pith; *b* primary cortex; *c* wood; *d* phloem; *x* pith of bud. Each small knot in the axils of the scales is the bud of a dwarf-shoot: see Figs. 11 and 12 (Ha).

with in many other buds, of which the Maples are further examples; and dissections of the buds of the Lilac, Lime,

Ash, Rose, &c. show the same general features, with differences in detail such as are illustrated in Figs. 5 and 6.

The bud of a Pine affords another example somewhat

Fig. 10.

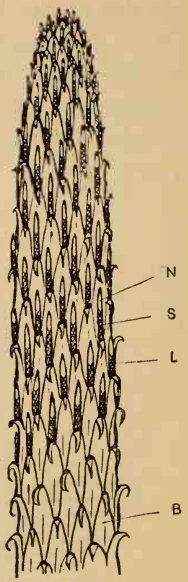


Fig. 11.

Fig. 10. Diagrammatic longitudinal section of a bud of a Pine. In the axil of all but the lowermost scales (reduced leaves) are buds which develop into dwarf-shoots (bifoliar spurs), each consisting of a few scale-leaves enveloping the base of two green needles. It is thus a bud of buds.

Fig. 11. Bud of Pine elongating, showing the spiral arrangement of the scales *B* and *L* (reduced leaves) each of which, except the lowermost, bears in its axil a bud of a dwarf-shoot; *N* foliage leaves of dwarf-shoot; *S* small bud-scales of same; *L* leaf-scale in the axil of which it stands.

more complex in structure than any yet described (Figs. 9, 10 and 11).

In the first place it has far more numerous scales

than the preceding—there may be a hundred or more—and these small brown scales are inserted spirally on the axis, and not in opposite pairs as in the Horse-chestnut. Then, as we gently tear off scale after scale, we find that each bears in its axil—i.e. in the angle which its base makes with the axis—a small bud (dwarf-shoot) composed in its turn of a few minute brown scales surrounding two as yet very short and slender green leaves placed face to

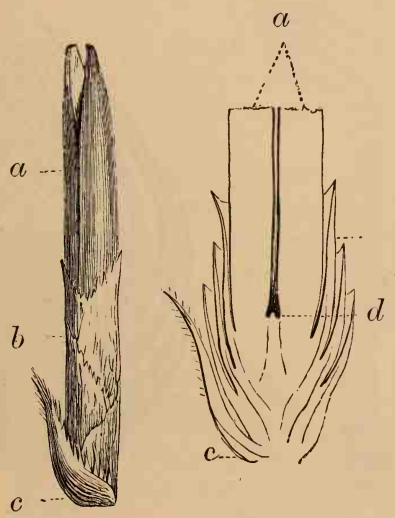


Fig. 12. Dwarf-shoot of Pine, just emerging from the bud stage: to the left slightly magnified, to the right in longitudinal section and more highly magnified. *a* the two green leaves face to face; *b* the sheath of brown scales (perulæ) surrounding them at the base; *c* the scale-leaf in the axil of which the dwarf-shoot stands; *d* the end of the axis of the dwarf-shoot (Wi).

face. The relative positions of these minute buds in the axils of the bud-scales are shown in Fig. 11, and one of the dwarf-shoot-buds itself, magnified, in Fig. 12.

Thus the Pine-bud is a bud of buds, and not simply a bud enclosing leaves, or leaves and flowers only, as in the former cases.

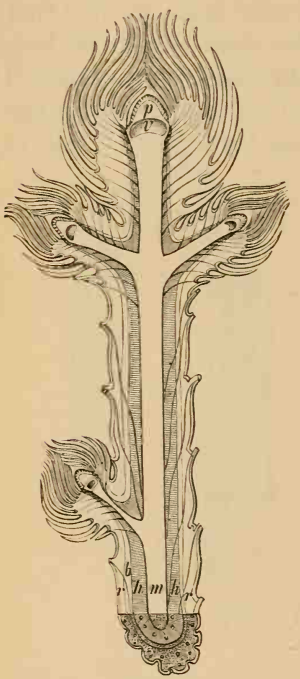


Fig. 13.

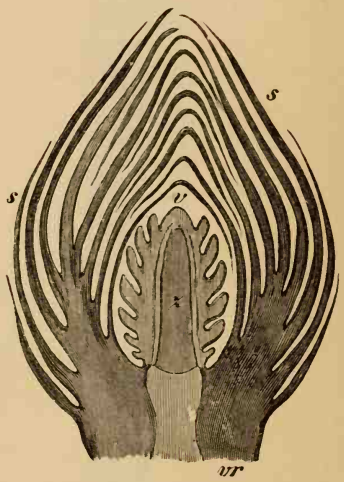


Fig. 14.

Fig. 13. Vertical section through buds of Spruce, *Picea excelsa*. *m* pith ; *h* wood ; *b* phloem ; *r* primary cortex ; *p* bud ; *v* cavity beneath the bud (Ha).

Fig. 14. Vertical section of bud of the Spruce, showing the numerous bud-scales *s*, inserted on a ring of tissue surrounding and investing the apex of the shoot *v* ; the latter bears the protuberances which will develop into leaves. *z* pith of shoot-axis ; *vr* cortex of shoot (Sa).

In the Firs, where the spirally arranged bud-scales are equally numerous, or nearly so, we have the same general

arrangement as in the Lettuce or Brussels Sprout, except that the outermost leaves are converted into true scales, enclosing the end of the axis bearing numerous small slender single leaves (Figs. 13 and 14).

In the Spruce we meet with the further peculiarity, that the true bud-scales are inserted on a common ring-like wall of tissue investing the base of the bud: when the bud "bursts" this ring separates off below and the whole mass of scales is carried up on the elongating bud like a cap.

In both the Pine and the Fir, we must conclude that each bud-scale represents a whole leaf, and not merely the lower portion of a leaf, and the same will be found to be true of many other buds.

We meet with yet a third class of cases in the Elm, Beech, Hornbeam, and many other trees. If we cut a section across such a bud, and magnify it somewhat, we shall find that every one of the folded up leaves in its interior is accompanied by two smaller, more or less leaf-like

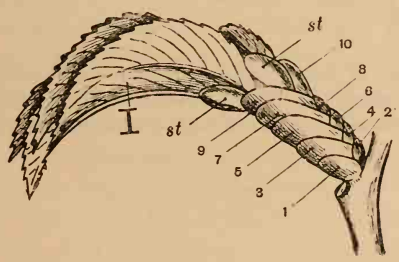


Fig. 15. Opening bud of the Elm in the axil of a fallen leaf, the scar of which is seen subtending the base. 1—10 stipular bud-scales; *I* first foliage leaf with its two stipules *st*. Other leaves just showing.

structures, which need explanation. Again the mystery is solved when the bud opens in spring, for, as shown in Fig. 15, these accessory structures are seen to be the

stipules, small flat leaf-like appendages, so common at the base of the stalks of the leaves of these and many other plants.

If now we compare the outer bud-scales of our Beech or Hornbeam, we find that they are arranged in pairs, just as are the stipules in the interior, but, unlike the latter, not every pair has a folded leaf between them. Careful examination shows that although the outermost pairs of bud-scales are devoid of any leaf between, some of the inner scales have a minute leaf-rudiment between each pair, as seen in Fig. 30.

Here, therefore, the true bud-scales enveloping the rest of the bud are neither leaf-bases, nor leaves, but stipules, and we shall find the same to be the case in many other plants.

Fig. 16. Bud of Beech just on the point of opening, and showing the leaves protruding each from between its pair of stipular bud-scales. Lower bud-scales, also stipules devoid of intermediate leaves (He).

CHAPTER III.

THE BUD—*continued.*

General characters reviewed—Formation of bud—Protective action of bud-scales—Number of leaves in bud—Sizes of buds—Shapes of buds—Buried buds—Extra-axillary buds—Accessory buds—Different kinds of buds on the same plant—Various kinds of bud-coverings—General nature of bud-scales—Terminal and axillary buds—Suppressed buds—Bud-sections.

A BUD, then, is the tip of a shoot surrounded by leaves, and, whatever its apparent position may be, it has been formed from the first shoot or plumule. Most buds as seen on a developed plant are either terminal, that is at the end of a twig or shoot, or lateral to that twig or shoot, and are usually produced in the axils of leaves, and in the case of deciduous trees and shrubs in winter—i.e. of plants which cast their leaves—the leaf-scar left by the fallen leaf will be found just below the bud. These statements are easily verified by examining a branch of Horse-chestnut, Ash, Oak, Currant, Walnut, Maple, Lilac, Poplar, Fig, Vine, &c.

The formation of a bud depends especially on the fact that the slowly-growing end of the shoot elongates less rapidly than some of the leaves it has itself produced, and these arch over the tip and protect it.

The protection may be for a short time only, or it may last for many weeks or months, as in the case of the winter buds of most of our woody plants. In the former case the leaves forming the bud are not much or even at all different from the ordinary leaves of the shoot; but in the latter case the leaf-structures which protect the tender tip of the shoot are often much altered in texture, form, and other peculiarities, and are called bud-scales.

The number of leaves, whether altered or not, which enter into the formation of the bud, and their arrangement

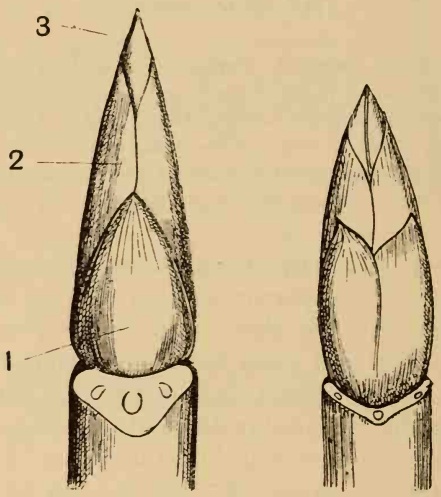


Fig. 17. Buds of Poplar, to the left, and Willow, to the right. The former begins with one anterior scale (1), a stipule, wrapping round the base of the bud: opposite to this is a posterior scale (2), the edges of which overlap in front: a third scale shows at (3). The latter begins with a double scale, representing two fused leaves; the inner leaves of the bud are bursting through (He).

as regards one another, vary according to the species, and the buds of different plants supply many characteristic marks used in determining systematic position.

The Ivy, for instance, has very few leaves in its bud, whereas in the Lettuce, &c. described as a type there may be over a hundred, while in some Pines there are between three hundred and four hundred. In the former of these instances the bud-leaves, moreover, are almost or entirely like those elsewhere on the shoot; but in such cases as the Pines and Firs, Walnut, Willow, Beech, Horse-chestnut and most trees the outer bud-scales are very unlike the young leaves inside the bud, or the older ones elsewhere, and may be very different in many ways. It is owing to these differences in the constitution, colour, size, position, &c. of buds that forest-botanists are enabled to compile diagnostic tables of the winter buds of trees and shrubs, very useful for determining species in the absence of the leaves.

Confining our attention now chiefly to the trees and shrubs with which this book is concerned:—

As regards size, the large buds of *Æsculus, Fraxinus, Magnolia, Ficus,* and *Acer platanoides* may be contrasted with the small ones of *Cydonia, Ulmus,* and *Acer campestre*; those of the Oak, Beech, and *Prunus Avium* stand about midway as regards size.

In shape most buds are more or less ovoid, but many modifications of the fundamental form are observable: for instance the long pointed buds of the Beech may be contrasted with the stumpy pyramidal ones of the Ash; or the typically ovoid buds of the Oak, with the flattened appressed buds of Willows, &c. As already stated, the usual position of the lateral buds is in the axils of the leaves: but in *Robinia pseudacacia* and in *Platanus* the lateral buds are apparently buried in the tissues of the base of the leaf-stalk, owing to the insertion of the latter enveloping the young bud as it forms. *Rhus typhina, Philadelphus, Cladrastis* and *Gleditschia* give other examples of these immersed or sub-petiolar buds.

These cases remind us of others which show that although the axillary position of lateral buds is so common among the higher plants as to be considered the normal, there are plenty of more or less evident exceptions. In the Beech, for example, the buds are laterally displaced from the axil, and still more so in *Monstera* and other Aroids.

Several trees have buds accessory to the axillary bud, and either superposed vertically above the latter (Ash, *Aristolochia Sipho, Lonicera Tartarica, Juglans cinerea,* Hornbeam, *Sambucus racemosa,* and *S. nigra, Cercis gymnocladus* and others), or placed laterally to it, as occurs in *Quercus ilicifolia, Salix nigricans,* Hawthorn, Red Maple, &c. In *Gleditschia* the superposed buds are very small and immersed.

In most cases the buds are placed directly in the axil, however, and closely sessile in it: the stalked lateral buds of the Alder owe their peculiarity to a slight growth of the shoot below the oldest bud-scale, a phenomenon which brings home to us the fact that the axillary bud is, after all, but the undeveloped branch.

Each branch, in fact, arises by the development of a bud, just as the whole shoot-system results from the extension of the plumule, or primary bud of the seedling. It follows that we may find buds of different kinds on the plant. In some cases the bud contains foliage leaves only arranged round the tip of the axis, and we may term these Leaf-buds; while other buds contain both ordinary leaves and flowers, and are called Mixed buds: others, again, may be Flower-buds. The differences between those buds which contain flowers and those which contain leaves only are well seen in *Cornus mas,* Poplars, and in some of our fruit trees, and the art of pruning these latter depends on a knowledge of these facts.

We have seen that the bud-coverings are essentially leaf-structures. Sometimes these bud-coverings are merely unaltered leaves, just like any other leaves of the plant, and this is probably always the case when the bud is merely the end of the still growing shoot, as in most herbaceous plants; but even in buds which are adapted for resting through the winter this is sometimes so. Such naked buds occur in *Viburnum nudum, V. Lantana, Rhamnus Frangula,* Juniper, and many herbs.

As a rule, however, the winter buds of our colder climates are covered with bud-scales of quite different texture from the foliage leaves: these scales are thrown off in the spring when the buds expand. The bud-scales may be simply dry, papery or leathery in texture, and brown (Beech, *Prunus Avium*), or greenish (Lilac, *Acer pseudoplatanus*); or more or less hairy (*Juglans, Betula pubescens, Carpinus, Ulmus,* &c.), velvety (Ash), glandular (*Hippophaë, Elæagnus, Betula verrucosa*), or viscid, owing to resinous or gummy excretions (*Alnus glutinosa, Populus canadensis* and *P. nigra*, and Horse-chestnut). In all these cases the texture, hairy covering, and resinous or balsamic excretions are protective, in that they prevent rapid changes of temperature and especially loss of moisture, and this protection is sometimes supplemented by cottony hairs covering the young organs inside the scaly covering, e.g. the Horse-chestnut.

The bud-scales (apart from those cases where they are obviously ordinary leaves) may be seen to be more or less modified leaves by tracing them from without inwards as the bud opens in spring. In the Lilac, *Lonicera* and *Daphne* the scales pass gradually into ordinary leaves and are modified forms of their blades: in *Magnolia, Liriodendron,* Alder, Beech, Oak, *Ficus elastica* and many others the bud-scales are stipules, the leaves to which

they belong being more or less suppressed or not, as the case may be: in *Æsculus*, *Acer*, *Prunus* (Fig. 32), &c. the scales represent the bases of leaf-stalks, the laminæ of which are more or less suppressed.

It has been shown that buds are usually either terminal or axillary, and it often happens that the terminal buds are larger than the axillary ones, and either solitary or flanked by two, three or more of the smaller axillary buds —e.g. Oak; and Spruce, Pine, Silver Fir, and other Abietineæ.

In many cases, however, the terminal bud is suppressed, or its growth stopped, so frequently that the phenomenon may be regarded as normal: obviously this affects the type of branching of the tree concerned. Examples occur in the Lilac where the terminal bud often fails to develop, or ends in flowers which then fall, and two opposite lateral ones continue the growth of the shoot, giving the effect of forked branching: less regularly, but not unfrequently, the terminal buds of the Horse-chestnut (Fig. 18) suffer a similar suppression, and still oftener their further elon-

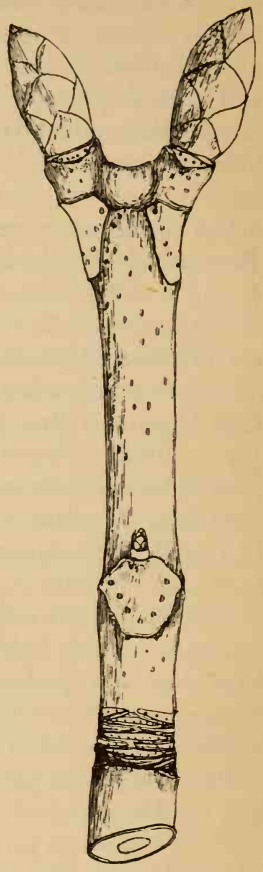


Fig. 18. Twig of Horse-chestnut, with two opposite lateral buds flanking the saddle-shaped scar whence the terminal inflorescence of last year has fallen, thus producing false dichotomy.

gation is arrested by their conversion into inflorescences, and the same occurs normally in the Mistletoe.

In the Elms, Lime, and some other trees, it is the rule in this country for the true terminal bud to be suppressed, and the axillary bud beneath it then swells and takes its place, the remains of the destroyed bud being only visible on careful examination. Similar cases occur in the Hazel, Hornbeam, Birch, *Robinia*, *Cercis*, and some Willows.

These suppressions of buds have an obvious bearing on the form of branching of the tree concerned, and this is still more strongly marked in the very common cases where certain axillary buds are always suppressed, here and there (*Philodendron*, Liliaceæ, Gramineæ), or at the base of the shoot (Oak, Beech, &c.), or even all over (*Papaya*, Palm). Such suppressed buds may be caused to develop further if an accident causes them to receive more supplies of water and nutritive materials than they would normally receive, as may be well seen in the development of the buds in the axils of the cotyledons of the Broad Bean if the plumule is destroyed, though otherwise they come to nothing.

The arrangement of the leaves and scales in the bud is so characteristic in some cases that sections may be employed for diagnosis—e.g. Ash and Sycamore.

The characters afforded by the winter buds and leaf-scars are largely employed by foresters in order to determine the species of deciduous trees in winter. Conifers and evergreens are not usually included in such schemes of classification, as they are more easily determined by the foliage: nevertheless we shall find interesting cases here also. Stipular scars are often observable by the side of the leaf-scars with a good lens.

Having thus indicated the general characters of the bud, we may now proceed to further details.

CHAPTER IV.

POSITION AND ARRANGEMENT OF BUDS.

Axillary buds and terminal bud—Opposite buds—Whorls and pseudo-whorls—Alternate buds, distichous or spiral—Displaced buds—Accessory buds, superposed or collateral—Aggregation of buds—Submerged buds.

THEORETICALLY every shoot terminates in a bud, and every leaf-axil on the shoot is capable of producing a bud, but the rule is that buds are not developed in the axils of the bud-scales, and in many cases there are none in several of the lower axils of the shoot, e.g. Beech, while in many Conifers buds capable of growing out to long shoots are only formed in very few of the numerous axils, e.g. *Abies, Picea,* &c.; nevertheless the general occurrence of buds in the majority of leaf-axils renders it easy to classify them into groups, as regards position. Thus the buds are opposite, as are also the leaves or leaf-scars subtending them, in the following:—

Clematis	Horse-chestnut
Maples	Sycamore
Mistletoe	Dogwood
Aucuba	Elder
Guelder Rose	Wayfaring Tree
Lilac	Privet
Ash	Honeysuckles
Spindle Tree	*Symphoricarpos.*

It is the rule where buds, leaves, &c., are opposite, that each alternate pair is directed at right angles to the pairs immediately above and below on the twig, and this decussate arrangement, as it is termed, prevails in all the genera in the above list. Cases occur, however, where buds which are not truly opposite, or not consistently so, but so nearly so as to be termed sub-opposite, are not always at the same time decussate. Examples are afforded by

Picea excelsa	*Rhamnus catharticus*
Abies pectinata	*Salix purpurea.*

In some of these cases, indeed, the buds, though strictly speaking not inserted at the same level, appear to be so arranged in whorls, or groups clustered round the stems in a radiating manner, that the shoots to which they give rise present the appearance of being in verticels, or regular tiers, at definite intervals. It is to this that the pseudo-whorls or false verticels of the following are due:—

Pines Spruces Silver Firs,

and, in a less pronounced degree, a similar arrangement occurs in

Larch	Ash	Oak
Cherry	Bird Cherry	Holly.

In the following, the buds are alternate, that is to say each bud stands isolated at its own node, the insertions being either alternately right and left of the twig bearing them, so that they are two-ranked (distichous) if regarded as to the vertical series formed by joining all the buds up the twig standing one over the other; or there are three or five such vertical series or ranks. In this latter case, a line joining each and every bud-insertion in succession would pass more or less spirally round

the twig, and this in such a way that if, starting from the lowermost bud, such a spiral line passes through three or five other bud-insertions as it completes its course round the twig to the next bud vertically above the one started from, then there will be three or five vertical ranks of buds respectively. In the case of the distichous, or two-ranked, arrangement, it is also true that a spiral line carried once round the stem from a lower bud to the bud next vertically above it passes two buds, and these facts can be expressed in a sort of shorthand.

Thus $\frac{1}{2}$ implies that the spiral line drawn as above passes once round the stem and passes two buds in its course; $\frac{1}{3}$ signifies that the spiral line in one complete journey round the stem from bud to bud passes three buds; and $\frac{2}{5}$ tells us that the spiral passes five buds in its course to the next bud vertically above the one we start from, but has to pass twice round the stem to do it. And similarly with other arrangements, but for our purposes it suffices to regard all cases of alternate buds as coming under two heads—the distichous or two-ranked arrangement, and spiral arrangements other than that.

Buds are obviously distichous on the longer twigs of the following:—

Elms	Hazel	Lime
Beech	Hornbeam	Chestnut.

Less conspicuously so in

Birch Ivy.

It is a noticeable feature in most of the above cases of distichous arrangement, that the bud is not exactly vertical over the leaf-scar if we hold the twig erect, but is displaced more or less to one side above the scar. This is very conspicuous in the Lime and Elms, but is observable in the others also. It is in some way connected with

the oblique or horizontal position of the branches, as they grow on the tree, but no satisfactory explanation exists to account for it.

Much more common is the spiral arrangement of alternate, as contrasted with opposite, buds and leaves. It prevails in

Alder	Robinia	Barberry
Walnut	Alder	Alder Buckthorn
Willows	Black Currant	Red Currant
Gooseberry	Poplars	Oaks
Roses	Sweet Gale	Mulberries
Blackberry	Apple	Pear
Laburnum	Sea Buckthorn	Plum
Almond	Hawthorn	Cherry
Furze	Blackthorn	Bird Cherry

and indeed in the majority of other trees and shrubs.

The commonest spirals in our native trees and shrubs are $\frac{2}{5}$ and $\frac{3}{8}$, but $\frac{1}{3}$ is not rare and may even occur simultaneously with $\frac{2}{5}$. But considerably higher numbers may prevail, and the scales on a cone of the Silver Fir may be $\frac{8}{21}$.

A somewhat curious state of affairs, as expressed sometimes in the branching, results from the habitual presence of two or more buds in some of the leaf-axils. In some cases the accessory buds—as the extra buds are termed—are found side by side, e.g. in *Symphoricarpos racemosa*, where there is usually one small bud on each side of the larger, or dominant, primary axillary bud, and evidently each developed in the axil of the lower bud-scale on its side. This is contradictory of the general rule that bud-scales are devoid of axillary buds. Other cases of collateral accessory buds are found in the Elder and in the allied *Sambucus racemosa*, sometimes accompanied by a lower bud as well, and in certain Jasmines and Maples,

Salix viminalis, Mulberries, and species of *Prunus*. In other cases the accessory buds are superposed, and it depends on the species whether the upper or lower bud of each group is the dominant one.

Another feature in the arrangement of buds, and with consequent effects on the branching which results, is the tendency to be grouped on particular regions of the twigs. In the Oak, for instance, most of the buds are clustered at the tips of the twigs, and in certain Cherries and their allies—e.g. *Prunus Padus*—the characteristic clusters of buds on the short lateral dwarf-shoots, or spurs, are very noticeable.

In the Pines (Fig. 9) and Firs (Fig. 13), again, very few of the leaf-axils carry buds capable of forming long shoots at all, but a cluster of axillary buds occurs at the tip of each branch, and when these grow out they appear as if all sprang from the same level, in whorls, whereas each bud is really at a slightly different level from its nearest neighbour. Similarly on the horizontal twigs of the Spruce, Douglas Fir and Silver Fir only a few buds are formed in one or two of the leaf-axils, though there may be hundreds of leaves on the twigs, and although these buds appear opposite or whorled, they are only approximately so, the leaves being always spirally inserted, as close observation shows. All these matters may have their effects in the branching which results from the elongation of the buds the following spring, and therefore on the form of the branch-system or crown of the shrub or tree concerned.

Yet another peculiarity of buds, as regards their position, deserves closer attention. In some cases, examination of the leaf-axils in summer or autumn, while the leaves are still on the tree, fails to disclose any buds at all. Nevertheless they are present, but are buried

beneath the tissues of the leaf-base. The most striking

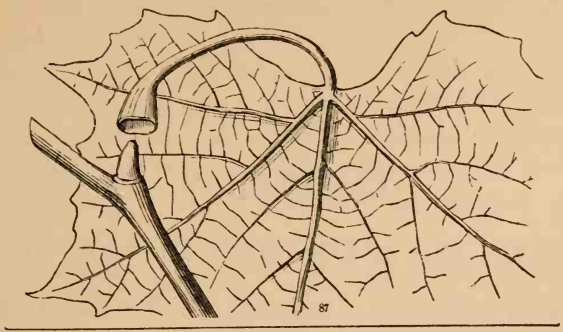


Fig. 19. Leaf of Plane, *Platanus*, detached to show the bud which was hidden in the base of the petiole, and the circular leaf-scar left round the base of the bud (G).

examples of this are afforded by the Plane (Figs. 19 and 20) and *Robinia*; in the former the bud is at once exposed on gently pulling off the leaf, the base of the petiole being found to leave an almost circular scar as a ring round the cone-shaped bud which was tucked in a funnel-like cavity

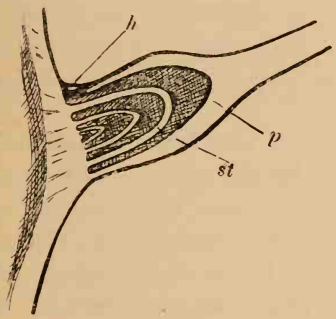


Fig. 20. Longitudinal section of the axillary bud of the Plane, invested by the base of the petiole *p* and communicating with the exterior only by the aperture at *h*. At *st* the cap-like investing stipules forming the bud-scales. Between these the cavities are filled with leaves bearing hairs.

now visible in the petiole. In *Robinia* there may be more than one bud, deeply buried in the tissues of the leaf-scar. In *Philadelphus*, also, the buds are thus buried.

CHAPTER V.

POSITION AND ARRANGEMENT OF BUDS—*continued.*

Number of buds on shoot—Leaf-axils devoid of buds—Accessory buds—Superposed and collateral buds—Dormant buds—Epicormic shoots—Suckers—Adventitious buds—Angle of insertion.

It will be seen from the foregoing that the number of lateral buds on a shoot just emerged from the winter rest in the winter bud is limited, because the number of leaves contained in such a bud is limited; though the fact must not be overlooked, that additions to the numbers may be made subsequently by outgrowths at the apex. This limit of the number of buds may vary considerably in different cases, and this depends on two principal classes of events.

The rule is that each perfect leaf forms a bud in its axil—i.e. in the angle formed by the upper surface of the leaf with the shoot bearing it; and that no buds are formed in the axils of the true bud-scales. But the rule has many exceptions. In the Birch, Hornbeam, Beech, Lime and some others, no buds are developed in the axils of the lowermost couple of leaves: buds also are commonly wanting in the axils of the crowded leaves of dwarf-shoots, e.g. Pine, Larch, Cedar, Beech, Alder, &c., and in Conifers generally buds which will give rise to

long shoots are developed only in the axils of a very few of the numerous leaves, e.g. Silver Fir, Spruce, Douglas Fir, &c.

On the other hand, the rule of one bud to each leaf-axil is broken by many plants which develop extra or accessory buds, either side by side with the truly axillary bud, or superposed on the latter in a vertical series, or even according to both modes of aggregation in the same axil.

For instance, the accessory buds are superposed in certain species of

Lonicera	*Carya*	*Sambucus*
Fraxinus	*Jasminum*	*Sophora*
Cercis	*Juglans*	*Rubus*
Celastrus	*Albizzia*	*Spiræa*
Cornus	*Laurus*	*Clerodendron.*

They are side by side, or collateral, in certain species of

Salix	*Punica*	*Polygonum*
Cercis	*Acer*	*Prunus*
Zelkova	*Symphoricarpos.*	

In certain species of the following the accessory buds occur both superposed and collateral:—

Aristolochia *Lycium.*

And in one and the same genus we may have the buds sometimes superposed, e.g. *Cercis canadensis*, *Sambucus nigra*; and at others side by side, e.g. *Cercis siliquastrum*, *Sambucus racemosa.*

These cases must not be confounded with those where buds are apt to be aggregated at the ends of the shoot, e.g. Oaks and *Prunus*; or where paired opposite buds occupy the apex, because the true terminal bud is aborted, e.g. *Syringa.*

As the shoot ages, there is frequently to be observed another breach of the general law, of one bud to each leaf-axil but none in the axils of the bud-scales.

It not unfrequently happens that buds which have been developed at the base of a shoot get no chance of opening and putting forth their shoots at the usual time, because the struggle for food-supplies, or water, results in their being left unprovided for: stronger shoots in other parts of the tree taking all the available stores. Nevertheless such starved buds do not always die, but they may lead a dormant life, and thus rest for years unobserved. Sometimes these minute buds are developed, after all, in the axils of the bud-scales at the base of the shoot, and may never come to anything.

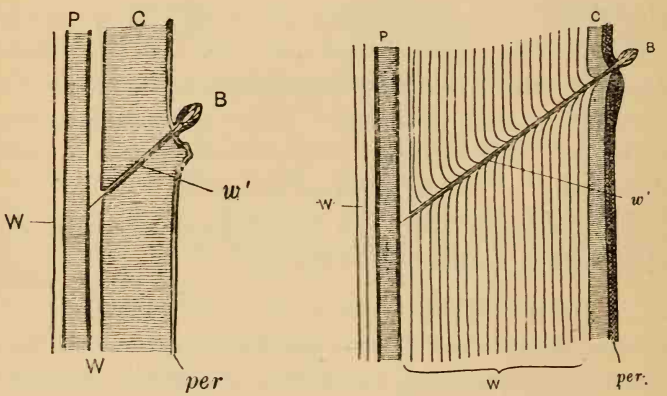


Fig. 21. Diagrams of longitudinal sections through a branch and its dormant bud, in the 1st and 20th years respectively. *B* the bud; *W* the wood; *w'* connection of bud with wood; *per* periderm; *C* cortex; *P* pith.

Years after their formation, however, such buds may be awakened to renewed activity if the parts of the shoot—by this time thickened and developed into a

branch—is removed by pruning, or broken off by wind, the weight of snow, &c. Or it may be that the necessary stimulus is supplied by the foliage being suddenly exposed to better conditions of nutrition, as, for instance, when a tree hitherto shaded by others is suddenly freed, and its leaves more exposed to light and air, by the felling of surrounding trees which prevented the access of light.

It is a common experience that Beeches, Elms, Limes, &c., thus suddenly exposed, cover their by this time thick and naked stems with what are called epicormic shoots, in some cases here and there, in tufts, in others from points so numerous that the whole stem is covered as by bushy outgrowths.

In most cases these epicormic shoots have sprung from dormant buds, which were developed years ago when the stem was a shoot, but which were never able to do more than just keep their heads alive on the surface of the thickening stem, and, in many cases, their tufted origin is explained by their being traced to buds formed in the axils of the bud-scales (Fig. 21).

Similarly are to be explained the more or less rich output of suckers from the base of the stem in such trees as

Black Poplar	Lombardy Poplar	Hornbeam
Alder	Maple	Ash
Oak	Elm	Scots Pine
Birch	Aspen	White Poplar
Robinia	Spruce	Silver Fir
Larch	Beech.	

These suckers or "gourmandizers" are frequently stimulated to further outgrowth as the result of cutting off the upper parts of a tree, or of the destruction of such

upper parts by insects, wind-breakage, &c., the removal of the powerful competitors for food-materials and water enabling the minute dormant buds to make use of the abundant supplies afforded by the powerful roots.

These cases are distinct from some others where adventitious buds—i.e. buds making themselves evident out of their proper order—arise on various parts of the stem, or even the root in exceptional cases, and give origin to shoots in quite exceptional places: these matters will be dealt with elsewhere.

The angle of insertion of the lateral buds on the long shoots differs considerably in different trees, and it commonly differs on one and the same shoot at base and apex. For instance, the buds of *Lonicera Xylosteum* stand out at nearly a right-angle with the shoot, while those of the Black Poplar and many Willows are erect and practically parallel with the shoot bearing them, or they may even have their tips incurved; those of the Beech diverge at an angle of about 45°, and those of the Hornbeam at a smaller angle with the parent shoot. But these angles of divergence are not always constant, and the Hawthorn, for instance, may afford examples where the uppermost shoots stand off at about 60°, those lower down at nearly 90°, while those at the base of the twig may form an even more open obtuse angle of 100° or so.

On the whole, the upper and stronger shoots make a more acute angle with the forward part of the parent axis than do those lower down, and although the original angles are not always kept as the shoots age, there can be no question that these general angles of divergence affect the form of branching and of the tree generally, as we shall see when considering that subject.

CHAPTER VI.

ANALYSIS OF BUDS.

Three principal methods—Dissection of bud—Examination of opening buds and ends of growing shoots—Transverse sections—Plan-diagrams—Method of preparing sections—Theoretical diagrams.

THERE are three principal methods of determining the structures shown in the interior of the bud. One of these is the direct dissection of the bud under the simple microscope, each scale and leaf in turn being removed by means of needles or by a delicate dissecting knife, as shown in Fig. 22, where the outer scales and leaves have been cut away, and the first of the complete foliage leaves exposed. In this way the transitions of scales to leaves, to stipules and so forth, can often be made out very clearly, and numerous details of texture, folding, &c. discovered. Carried to its limits this mode of dissection from the outside may bring to us a clear view of the arrangement of the leaves on the axis, as shown in Figs. 23 and 24, where the cut leaf-bases and vascular bundles are seen, plainly decussate in the Lilac, and, with equal distinctness, distichous in the Lime.

A second method is to study the opening buds, or to dissect the end of the growing shoot, and make out the

disposition of the leaves as they pass out of the bud state to the stage of expansion. This can often be done with great ease in the open, as for instance in the case of the Vine shoot shown in Fig. 25, or in the series of opening Beech-buds shown in Fig. 26.

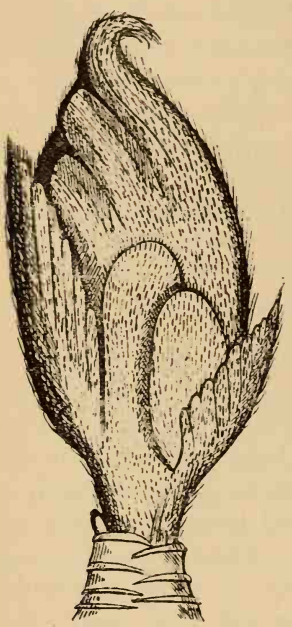


Fig. 22.

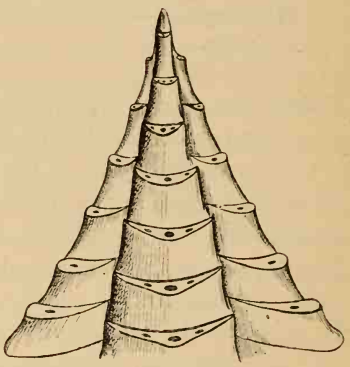


Fig. 23.

Fig. 22. Interior of bud of the Mulberry, *Morus*, showing the overlapping young leaves with their stipules. The scars of the removed leaves below, and a bud in the axil of the leaf last dissected away (He).

Fig. 23. Terminal cone of a bud of the Lilac with the bud-scales and most of the young leaves dissected off. The youngest leaves still remain at the apex. The scars exhibit the strictly decussate arrangement. Highly magnified.

For a complete analysis of the structure and morphology of the bud, however, it is necessary to combine a third

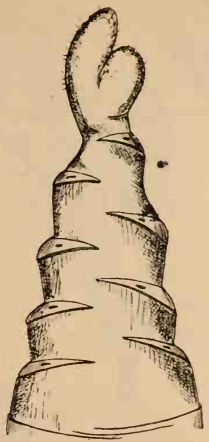


Fig. 24. End of the vegetative cone of a Lime-bud from which the bud-scales and most of the young leaves have been dissected off. The scars of the latter are seen in distichous order up the two sides. At the top is one of the youngest leaves with its stipules, which on removal would show still younger leaves inside. At the base the scars of the bud-scales. Highly magnified (He).

Fig. 25. Partially dissected opening bud of the Vine, *Vitis*, showing a leaf with its stipule to the left, overlapping other stipules and leaves: to the right a young tendril.

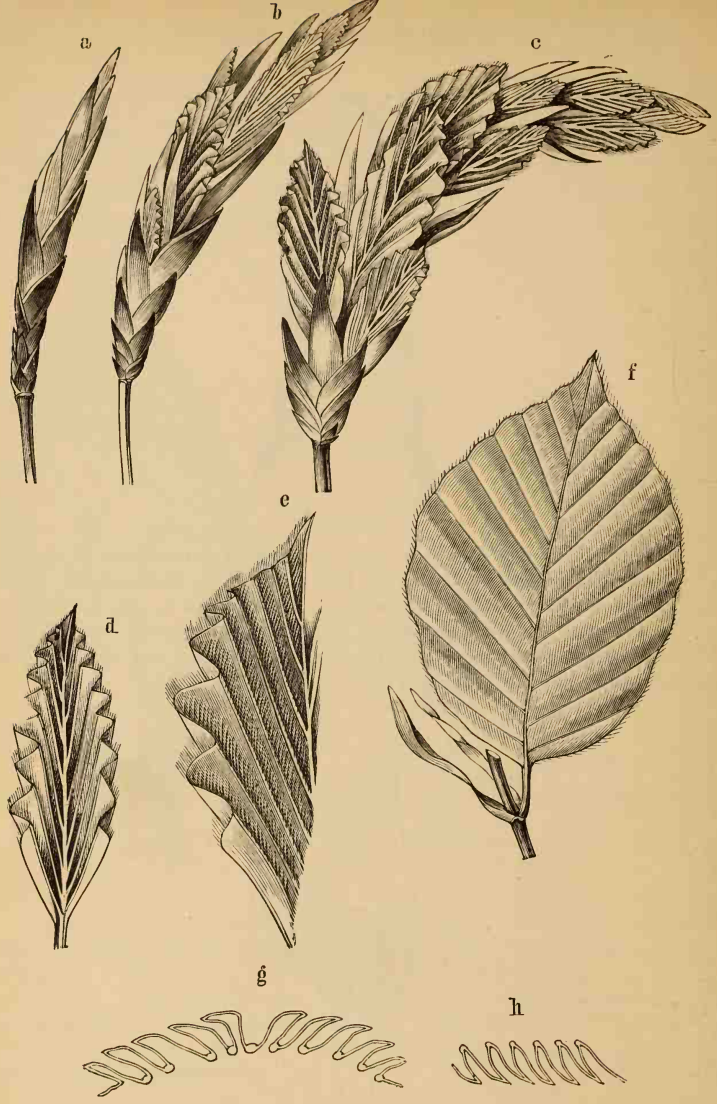


Fig. 26. Unfolding of leaves of the Beech, *Fagus*. *a* loosening of the brown and red stipular scales; *b* and *c* further stages, showing the plicate leaves protruding from between each pair of stipules; *d* a plicate ciliate leaf expanding; *e* portion of same magnified; *f* leaf expanded and stipules about to fall; *g* transverse section across the folds in *e*; *h* longitudinal section parallel to midrib in *e* (K).

method with the two already mentioned, and that is the study of transverse sections of the bud. These are easily obtained now that laboratory methods of hardening and cutting have reached so high a stage of development, and although much useful information can be obtained from a single clean cut across the middle of the bud, the student must remember that more than this is needed to elucidate the structure of a whole bud.

For instance, in Fig. 27 we have a transverse section across the bud of a Poplar, which shows us many details as to the arrangement of the bud-scales, the involute

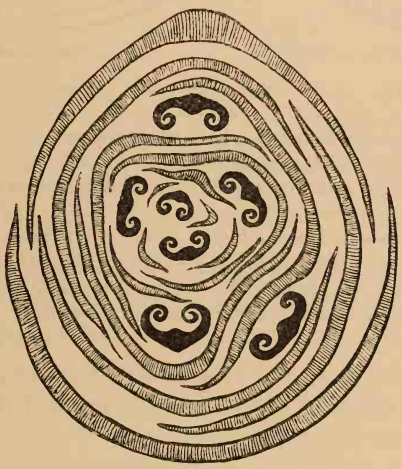


Fig. 27. Transverse section of bud of Black Poplar, *Populus nigra*, showing spirally arranged bud-scales (stipular) and involute leaves each with its pair of stipules.

leaves and so forth; but there is nothing to show that we have the bud in its proper position, or that we have drawn all the scales and leaves composing it.

In the cases shown in Figs. 28 and 29, illustrating the

plan-diagrams of buds of *Rhamnus* and Elm respectively, a certain proportion of theory is expressed in the diagrams, by the insertion of a conventional sign ⊕ indicating the

Fig. 28.

Fig. 29.

Fig. 28. Plan-diagram of a bud of *Rhamnus catharticus* with the outer bud-scales opposite, gradually passing inwards to obvious pairs of stipules overlapping at the edges, the innermost with their accompanying, opposite, involute leaves.

Fig. 29. Plan-diagram of a bud of Elm, the outermost (stipular) bud-scales distichous and overlapping at the edges, gradually passing to pairs of stipules with their leaves. The latter distichous, and conduplicate with the margins directed towards the axis of the shoot.

position of the axis, and of a leaf of the axis, at *a* and *c* respectively, showing the position of the leaf in the axil of which the bud was developed.

This leads us then to the distinction between a mere diagram of a transverse section of the bud and a plan-diagram in which is indicated more than can be seen in a section at any one level. In the preparation of the latter it may be necessary not only to examine sections at various levels, but also to introduce features not actually existing —e.g. the hypothetical leaves which would be found in the positions of the numbers between the stipular scales

in the Oak, in Fig. 30, but which may be inferred from comparison of dissections and sections of numerous species.

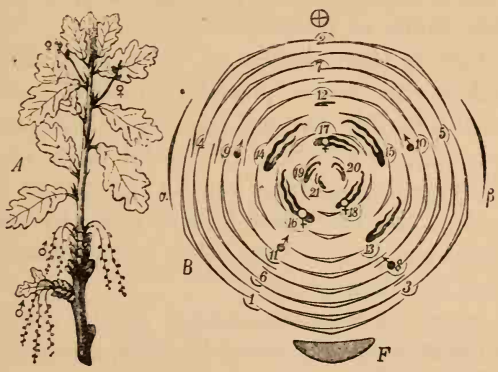


Fig. 30. Oak, *Quercus Robur*. *A* flowering shoot, with male catkins ♂ and female clusters ♀. *B* plan-diagram of the bud, showing the numerous stipular bud-scales in five ranks outside, and the spiral leaves, each with a pair of stipules, inside. The numbers indicate the sequence in the spiral, and are placed in the position of the leaf which would belong to each pair of stipules. *F* subtending leaf (Ei).

Since there is room for much more investigation along these lines, it may be interesting to refer to the laboratory methods adapted to the preparation of serial sections of buds.

The bud is first hardened in any suitable fluid such as absolute alcohol, chrom-acetic acid, or Flemming's fluid, so that the delicate leaves and axis inside may be made sufficiently tough to resist tearing as the razor passes suddenly from the scales to the interior: about a day is necessary for this. In some cases it may be necessary to remove the hard outer scales in order that the fluids may penetrate. It is then thoroughly washed to remove the chromic acid or Flemming's fluid, if such are employed, and placed successively in alcohols of 50 °/₀, 70 °/₀,

90 °/₀ strength, and then in absolute alcohol, the times varying according to the texture and size of the bud: large buds sometimes need piercing or even cutting to enable the fluids to penetrate.

The bud is then soaked in xylol until thoroughly impregnated, and finally placed in melted paraffin-wax and kept at about 60°C. until thoroughly interpenetrated. On now mounting the bud, in a solid block of paraffin obtained by cooling, sections can be cut in any direction and sequence and the plan-diagram made by comparing them, additional information being added, obtained from comparison by other methods.

The extent of information that can be conveyed by properly drawn diagrams is considerable, and may be well seen in Fig. 31, where the relations between the parts of a whole shoot of a Lime, and the incepts of the further shoots in its buds, &c., are expressed in one plan.

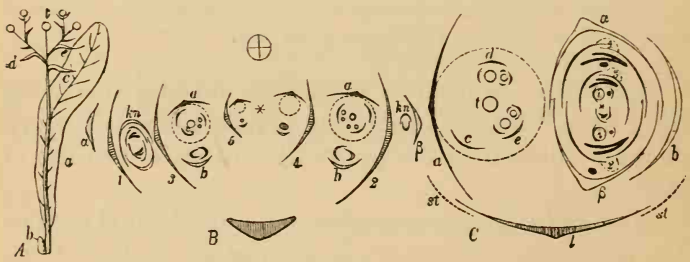


Fig. 31. Lime, *Tilia*. *A* inflorescence; *a* the adherent bract; *b* bud; *c*, *d* and *e* bracteoles; *t* terminal flower. *B* plan-diagram of a whole shoot; ⊕ axis; *B* subtending leaf; *kn* bud in axil of leaf 1; *a* bract as in *A*; *b* bud-scale of bud *b* in *A*; α and β bud-scales of bud from which the whole shoot sprang; 1—5 order of development of leaves with inflorescences. *C* plan-diagram of inflorescence, with its bract *a*, and bud *b* of *A*, in axil of leaf *l*. Letters as before. *st* stipules of the subtending leaf *l* (Ei).

CHAPTER VII.

THE BUD-SCALES.

Leaves or leaf-structures—Simple buds covered by leaves—Naked buds—True scales—Transitional forms—Reduced leaves—Numbers of scales visible—Arrangement of scales—Opposite and decussate scales—Whorled scales—Distichous and spiral scales—Transitions from distichous to spiral—Functions and structure of bud-scales.

When the buds begin to swell and "burst" in the spring, it is easy to convince ourselves that the bud-scales which envelope them, or the outermost coverings which do not present the brown colour, membranous or leathery texture and other peculiarities of true scales, though not always of exactly the same nature, are, generally speaking, leaf-structures or appendages, however much they may be altered in detail: their insertion, venation, relation to buds in or near their own axils, &c., all bear this out. A similar conclusion is arrived at by dissecting and comparing various buds. The chief results of investigations in this domain may be summarized as follows.

In certain cases the outer envelope is of the same nature as in the large green buds of the Brussels Sprout, Cabbage and Lettuce which we took as our first simple type of a bud; that is to say they are merely ordinary green leaves, not essentially different from the rest of the

green leaves folded up inside the bud. Buds thus devoid of a scaly envelope are termed naked, or open, and occur in the following trees and shrubs:—

Viburnum Lantana	*Rhus typhina*	Alder Buckthorn
Barberry	Bittersweet	*Lycium*
Mistletoe	Juniper	Ivy.

In the Elder the outermost bud-coverings are scales, but they cover the inner leaves of the bud so incompletely that the latter is sometimes termed half-open, and something of the same kind results from the very early and rapid elongation of the buds of the Honeysuckles, and some other plants.

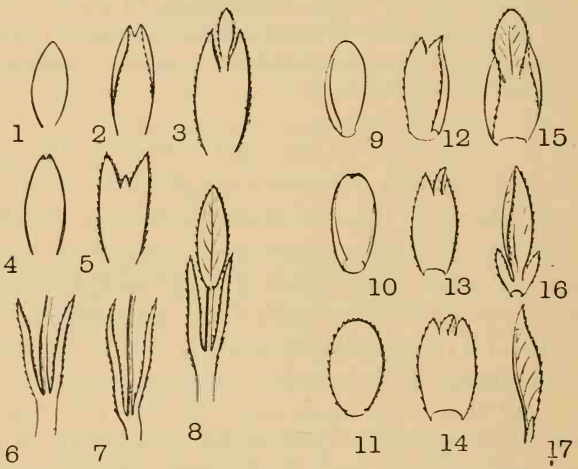


Fig. 32. Bud-scales and young leaves in order of succession from a bud of *Prunus Avium*. Nos. 1—8 dissected from the resting bud; Nos. 9—17 from a bud in process of development into a shoot in spring. 1 and 9 are merely scales; 2 and 12 are notched at the apex into two teeth; 5, 13 and 14 show a trace of lamina at the base of this notch. In 3 and 15 the lamina is more distinct; and in 8 and 16 the stipular nature of the two teeth is evident. 6 and 7 completed stipules. 17 complete young conduplicate leaf. (After Henry, *Knospenstudien*, 1846.)

Where true scales occur, they may be of several different kinds.

In the following they are simply leaves, often retaining their essential leaf-characters, and even in part their green colour and herbaceous texture, but reduced in size and frequently brown and membranous, as if scorched, at the margins or elsewhere; sometimes they are wholly membranous. Such reduced leaves occur in

Rhamnus Frangula	Pines	Larch
Honeysuckle	Cedars	Lilac
Privet	*Daphne*	Yew
Azalea	*Euonymus*	Holly
Firs	Rhododendron	*Cornus.*

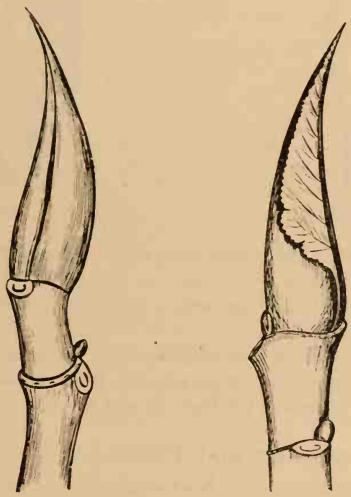


Fig. 33. Bud of the Fig. That to the left with its outer scale (stipule) still completely folded round it. That to the right with the outer scale removed, showing the leaf folded round an inner stipule, which, if removed would expose a similar leaf superposed on another enfolding stipule, and so on.

The bud-scales are the bases of reduced leaves in the Bird Cherry, as shown in Fig. 32, and also in

Horse-chestnut	Maple	Plum
Portugal Laurel	Sycamore	*Myrica*
Cherry	Ash	Walnut
Elder	Bird Cherry	Laburnum
Guelder Rose	Beam Tree	Cherry Laurel.

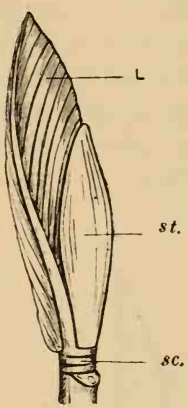


Fig. 34.

Fig. 35.

Fig. 34. A bud of the Alder from which the outer scales have been dissected off, showing a folded and plaited leaf *L* with its stipule *st.* *sc.* scars of the dissected off bud-scales (stipular) just above the leaf-scar. The bud is shortly stalked.

Fig. 35. Bud of Plane just opening. The leaves are bursting through the closed envelopes formed by the stipules, leaving the latter as cup-like investments at their base. Cf. Figs. 19 and 20 (H).

In the Fig, Alder and Plane (cf. Figs. 33 to 35), as also in the following, the bud-scales are stipules:—

Chestnut	Elm	Oaks
Lime	Hornbeam	Hazel
Rose	Blackberry	Buckthorn
Pear	Birch	Apple

Vine	Poplars	Willows
Guelder Rose	Ampelopsis	Hawthorn
Mulberry	Hop	Magnolia
Beech	*Ailanthus.*	

The number of bud-scales varies considerably. While the Willows, for instance, only present a single scale to the external view—really formed of two scales fused into one—the buds of many Pines and Firs may have as many as a hundred to three hundred and fifty. Very useful characters for diagnostic purposes are afforded by the practically constant number of scales observable externally in each species. Thus, there is but one scale exposed in

Willows Guelder Rose.

Two or three scales are visible in

Lime	Alder	Plane
Sarothamnus	Bittersweet	Fig
Vine	*Ampelopsis*	*Hippophaë*
Laburnum	Chestnut.	

There are about two to four exposed in

Dogwood Privet Ash.

The following have several scales, i.e. about five or six to ten or a dozen visible:

Black Currant	Gooseberry	Red Currant
Walnut	*Ailanthus*	Birch
Sweet Gale	Mulberry	Barberry
Rose	Blackberry	Poplars
Daphne	Apple	Pear
Rowan	Beam	Hawthorn
Cherry	Blackthorn	Clematis
Cotoneaster	Elms	Birch
Hazel	Buckthorn	Sycamore
Maples	Horse-chestnut	Lilac
Spindle Tree	Elder	*Symphoricarpos.*

Twenty or more scales are visible in

Oaks	Bird Cherry	Plum
Azalea	Beech	Hornbeam
Rhododendron	Honeysuckles.	

Numerous scales, up to a hundred and more, occur in

Larch	Silver Fir	Cedars
Pines	Spruce.	

The arrangement of the bud-scales in the bud also presents several features of interest.

In trees with opposite and decussate leaves and buds, the scales of the latter are usually also opposite and decussate, so that transverse sections across such buds present a more or less quadrilateral figure, sometimes with further angularities due to the midribs of the scales when such are pronounced. This type of bud with decussate scales is found in

Ash	Privet	Lilac
Spindle Tree	Maples	Sycamore.

The general contour is more rounded, though the scales are still opposite and decussate in the following:—

Horse-chestnut	Norway Maple	Honeysuckles
Elder	Dogwood	Guelder Rose
Mistletoe	*Staphylea.*	

In the Juniper the bud-scales, which are leaves, conform to the arrangement of the foliage, and are in whorls of three.

In shrubs and trees with alternate leaves, two types of arrangement are commonly associated with the prevalence of distichous or spiral buds and leaves respectively, but it should be noted that stipular scales are usually twice as numerous as the leaves they would belong to, and are not

necessarily arranged in precisely the same way. The bud-scales are more or less obviously distichous or doubly distichous in

Lime	Apple	*Camellia*
Celtis	Pear	Elms
Chestnut	Beech	Hornbeam
Hazel	Mulberry	*Aristolochia*
Ampelopsis	Vine.	

In the following the outer bud-scales or leaves are distichous, but they often pass inwards to some form of spiral arrangement:—

Ivy	Bilberry	Birch
Chestnut	Hazel	Lime
Beech	Hornbeam.	

They are spirally imbricate in

Rhus typhina	Barberry	Bittersweet
Ailanthus	Holly	Fig
Alder	Walnut	*Daphne*
Beam	*Arbutus*	Broom
Prunus	Rowan	Laburnum
Larch	*Azalea*	*Rhododendron*
Pines	Firs	Mulberry
Black Currant	Red Currant	Gooseberry
Blackberry	Roses	Oaks
Poplars	Birch	Cherry
Bird Cherry	Buckthorn	Hawthorn

and Willows (except *Salix purpurea*).

The functions of the bud-scales have been investigated by Grüss, whose results may be thus summarized.

In *Cornus sanguinea*, the Vine and some others, starch, and in *Lonicera*, the Willows, &c., oil is stored as reserve food-materials in the scales.

The cork-layers found in most scales, as well as hairs and resin, are useful in preventing undue loss of water, and the removal of such scales usually involves the desiccation and death of the young leaves inside, though differences exist with regard to the endurance of the de-

Fig. 36.

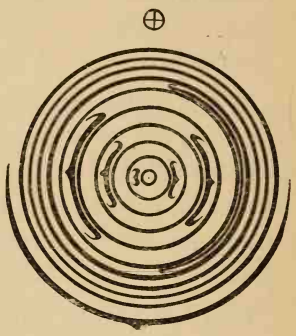


Fig. 37.

Fig. 36. Plan-diagram of a bud of Magnolia, the scales of which are closed stipules, enveloping the distichous conduplicate leaves: the edges of the latter directed towards the axis of the shoot. *B* leaf in the axil of which the bud is situated.

Fig. 37. Diagram of bud of the Plane in plan. Between the axis ⊕ and the subtending leaf, the bud is composed of successive envelopes of closed stipules, between the inner of which lie the distichous revolute leaves.

nuded buds of different species. For instance, the denuded buds of the Beech endured far longer than those of the Oak, because the leaves of the former are covered with silky hairs, and, for similar reasons, the buds of the Horse-chestnut withstood desiccation very well.

The following classes of protective scales were made out. In the Spruce, Oaks, Willows, Rhododendron, &c. the scales have a markedly thickened cuticle. Most Conifers, the Black Poplar, &c. have similarly protected scales,

between which resin is poured out and cements them together. In the Lime, *Ailanthus glandulosa*, *Lonicera*, &c. the scales have decided cork-layers as an extra protection. In the Maples, Sycamore, Beech, &c. the scales as well as the young leaves invested by them are provided with hairs, which often mat themselves together. In the Oaks, Vine, &c. the outer scales have the corky layers referred to, while the innermost scales bear interwoven hairs. In the Silver Fir, Pines, Birch, &c. the outermost scales have cork-layers, and resin is poured out in addition. In the Plane the bud-scales are smeared with resin, while the enclosed young leaves and axis of the bud are very hairy. In the Horse-chestnut the outermost bud-scales have cork-layers, and resin is poured out over them, while the inner organs of the bud are densely covered with interwoven hairs.

As regards temperature, no covering of bud-scales can prevent the inner parts of the bud from chilling during a long frost, and we must not forget that naked buds often withstand the severest winter; consequently we must assume that the resistance to cold is an adaptive character of the enclosed leaves themselves.

Moreover, many buds open very early in spring, and the removal of the bud-scales, if care be taken that the exposed buds are not allowed to dry up, often results in no damage from cold, though to this rule there are exceptions.

CHAPTER VIII.

ARRANGEMENT OF LEAVES IN THE BUD.

Not necessarily that of the bud-scales—Leaves decussate—distichous —spiral—Folding of leaves in bud—Conduplicate—Direction of folding—Convolute—Involute—Revolute –Plicate—Plane.

THE arrangement of the young leaves in the interior of the bud is by no means necessarily the same as that of the bud-scales, though the exceptions chiefly concern those cases where the scales are stipular.

In the Juniper the leaves in bud are throughout in whorls of three (Fig. 38).

Fig. 38.

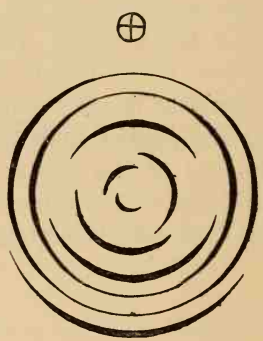


Fig. 39.

Fig. 38. Plan-diagram of bud of Juniper, consisting of alternate whorls of three leaves each, the outer serving as bud-scales.

Fig. 39. Plan-diagram of a bud with the outer bud-scales opposite, passing into a spiral. The scales are reduced leaves, e.g. Willow. The leaves are neither folded nor rolled.

In the Willows the leaves in the bud are almost invariably spirally arranged in the interior, though the outer leaves may be distichous or opposite (Fig. 39). In the Oaks the bud-scales are imbricated spirally, but so as to form five ranks, a very characteristic feature, and the leaves are spiral (Fig. 30).

In the following the young leaves in the bud are opposite and decussate:—

Mistletoe	Maples
Sycamore	Honeysuckles
Lilac	Spindle Tree
Dogwood	Horse-chestnut
Ash	*Viburnum*
Rhamnus catharticus	Coffee.

In the following the young leaves are distichous:—

Aristolochia	Plane	Magnolia
Chestnut	Hazel	Cherry Laurel
Lime	Beech	Hornbeam
Camellia	Virginian Creeper	Vine.

In the Ivy, Bilberry, Birch, and some others, they commence by being distichous, but pass sooner or later to a spiral arrangement.

In the following the young leaves are spiral in bud:—

Broom	Roses	*Arbutus*
Ailanthus	*Azalea*	Rhododendron
Daphne	*Laurus*	Holly
Walnut	Mulberry	Elms
Prunus Avium	Cherry	Apple
Pear	Alder	Fig
Oaks	Poplars	Pines
Firs	Larch	Cedar

Willows (except *Salix purpurea*).

The manner of folding of the young leaves in the bud, apart from the scales, is also characteristic in some cases; e.g. in the Blackthorn, *Prunus spinosa*, the young leaf-blades are rolled up on the vertical axis with the upper surface interior, so that one edge is inside and the other outside (*convolute*); but in the closely allied Cherry and Bird Cherry, *P. Cerasus* and *P. Padus*, the leaves are folded on the midrib, so that the two upper half-surfaces oppose one another like the leaves of a book (*conduplicate*), characters which can be utilised in diagnosis (cf. Fig. 29).

The young leaves or leaflets are conduplicate in the following:—

Cherry	Bird Cherry	Oaks
Elms	Hazel	Blackberry
Rose	Vine	Ash
Magnolia	Cherry Laurel	Lime.

Moreover, differences are to be met with in further details of the arrangement. For instance, the young leaves are so folded in Magnolia that their margins all point towards the axis of the shoot on which the bud is borne, their midribs being directed away from it and pointing towards the leaf in the axil of which the bud stands (Fig. 36), and the same arrangement holds good for the Elms, Hazel, Cherry Laurel, and Lime. In the Oaks, and most species of *Prunus*, however, e.g. *Prunus Amygdalus, P. Avium, P. Cerasus*, &c., the margins are so directed as to follow the spiral developed by connecting the leaf-insertions. In the Roses the margins of the conduplicate leaflets are all turned towards the centre of the bud itself; while in the Tulip Tree (*Liriodendron*) the directions of the margins are reversed in each succeeding leaf, alternately pointing towards the axis of the parent shoot and away from it.

In the following the young leaves are so rolled inwards that one margin covers the other (*convolute*):—

Blackthorn Plum.

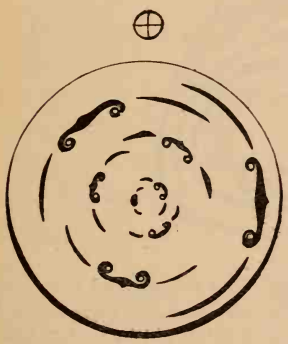


Fig. 40.

Fig. 41.

Fig. 40. Plan-diagram of a bud with spiral, involute, stipulate leaves, the bud-scales of which are stipular, e.g. Apple, Poplar, &c.

Fig. 41. Diagram of plan of bud of *Azalea*, showing spiral arrangement of bud-scales (reduced leaves) and revolute young leaves.

In the following the two edges of the leaves are rolled in towards the midrib, the inrolling being such that the upper surface is the concave one (*involute*):—

Black Poplar, White Poplar, Apple, Pear, and the leaflets of Walnut and *Staphylea* (Fig. 40).

While in the following the edges are similarly inrolled towards the midrib, but on the opposite surface, so that the lower side of the leaf is concave (*revolute*); see Figs. 37 and 41:—

Plane Azalea Rhododendron.

Finally, attention may be directed to cases where the leaves have their surfaces crumpled or folded in other

directions, and without reference to the rolling or folding on the midrib.

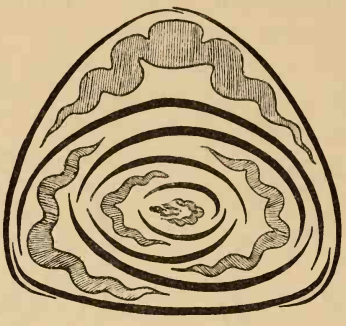


Fig. 42. Diagram of plan of Alder-bud. The young leaves are plicate, and each has its two stipules, those of the outermost leaf (uppermost in figure) form the principal bud-scales, the third of which, below, is the outer stipule of the second oldest leaf.

Fig. 43. Opening bud of Beech, *Fagus sylvatica*, showing the plicate leaves with their stipules escaping from the stipular bud-scales (Wi).

The leaves are folded in a fan-like manner (*plicate*) in the Alder (Fig. 42) and

Maple	Sycamore	Black Currant
Red Currant	*Hamamelis*	Beech
Hornbeam	Warfaring Tree	Birch.

In other cases, and especially when the leaf is fleshy, or its surface small, there is no folding at all, the inner face of each leaf lying on the outer face or margins of those within—i.e. the leaves are plane or merely slightly curved and follow the surface of the bud (Figs. 38 and 39). Examples are

Mistletoe	Privet	Honeysuckles
Lilac	Spindle Tree	Ivy
Aristolochia	Broom	*Arbutus*
Daphne	Laurus	Holly
Rhamnus catharticus	Mulberry	Chestnut
Fig	Pines	Willows
Firs	Juniper	Larch
Cedars	*Thuja*	Tamarisk
Yew.		

CHAPTER IX.

THE OPENING OF THE BUD AND EXTENSION OF THE SHOOT.

"Swelling" and "bursting" of the bud—Due to thrusts of expanding leaves—Vertical section of bud—The same after extension—Further development of Shoot—The winter state—True terminal buds—Aborted buds—Shoots and Twigs—Annual growth of shoot—Leader—Periodic growth—Maximum extension—Variations in growth—Secondary growth—"Lammas shoots."

When the bud "swells" and "bursts" in spring, two principal actions are at work, though both are due to one fundamental property of the young organs.

The first of the two actions referred to is the upward thrust of the growing apex of the shoot as it elongates. This process has often been compared to the extension of a telescope, as the segments are pulled out, and the illustration is apt in so far that the bud-axis does grow especially at the internodes between the nodes, thus driving the leaves or pairs of leaves further apart, but it is a far more complex process than the illustration of the telescope would suggest, and the analogy must not be pushed far. The most essential distinction is that in extension by growth there is ultimately an addition of material, brick on brick as it were, to the substance of the segments.

The second of the two actions referred to is the outward thrust of the expanding leaves and stem, which drives the bud-scales asunder. Both of these actions are referable to the same cause, the absorption of water by the millions of minute microscopic cells of which the young leaves and the tip of the axis bearing them are composed, and their consequent growth. We know from experimental evidence that the pressures exerted by such growing organs may be enormous.

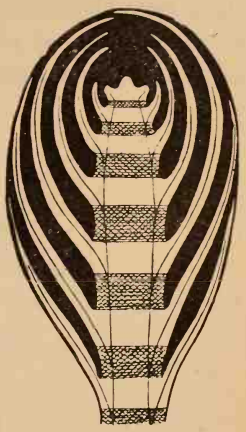


Fig. 44. Diagram of a bud with opposite leaves and bud-scales, in longitudinal section. The nodes are left unshaded; the internodes are shaded. The axis bears seven pairs of scales or leaves, in various stages of development, covering and protecting the vegetative cone at the apex. See Fig. 45 for further development.

In the diagram of a bud in vertical section, shown in Fig. 44, the axis bears seven pairs of appendages, inserted at the levels left unshaded, i.e. the nodes. The lowermost two pairs are true bud-scales, we will assume, and the next inner pair are intermediate scales; then come four pairs which will be true foliage leaves, though at present they are very young.

In the diagram, Fig. 45, we have a representation of the relative state of affairs when the bud has "burst," and the young shoot elongated. The two pairs of bud-scales at the base have been thrown outwards, and will soon fall off, and we observe that they have neither grown in length nor been driven further apart by any essential elongation of the internode between them: nor do they bear buds in their axils. The next pair of organs have elongated, and developed a rudiment

of a leaf-blade at the tip, and the internode separating them from the bud-scales is appreciably, though slightly, longer than it was in the bud. These intermediate scales again have no axillary buds, and will soon fall.

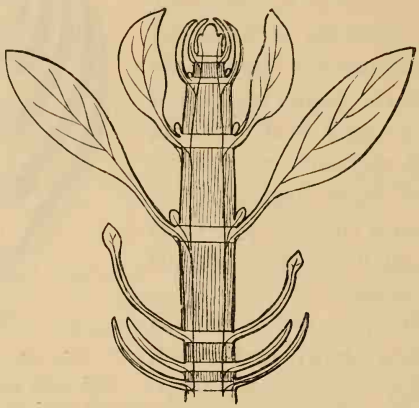


Fig. 45. Diagram of the elongating shoot developed from the bud of Fig. 44. The two lowermost pairs of scales have no axillary buds, and the internode between their insertions does not elongate; the next internode scarcely elongates and the scales, also devoid of axillary buds, show traces of lamina at their tips. The succeeding internodes are elongating and the true leaves borne at the nodes have axillary buds. Uppermost leaves and internodes not yet elongated.

But the changes apparent in the next two or three internodes are considerable, for not only have the internodes elongated to several times their length in the bud state, but the leaves have expanded and become larger and are no longer curved in at the tips; moreover buds have been formed in their axils.

At the tip, the temporary protection of the extreme apex is still provided for by the curving over it of the still young leaves: not only the uppermost pair which we counted in the bud (Fig. 44), but also others which are being formed anew at the advancing apex.

It will thus be clear that the extension of the shoot depends essentially on the successive extension of internodes by growth in length, and it is a general rule that the extension begins slowly in the spring, then reaches a

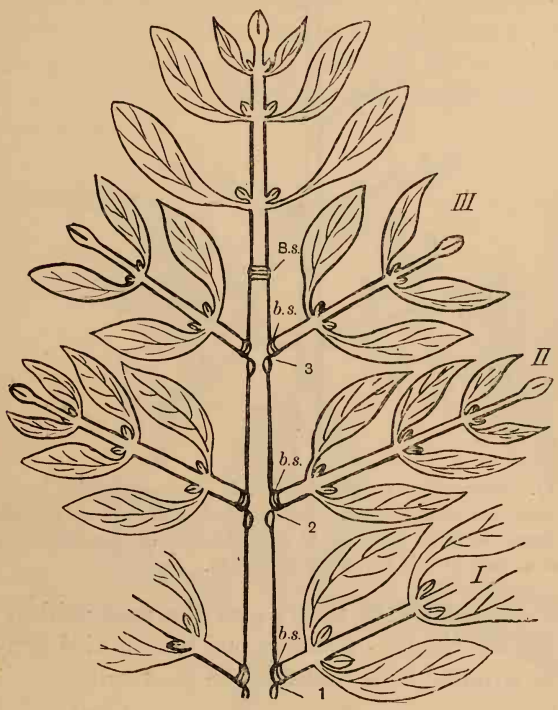


Fig. 46. Diagram of a shoot in the second year of its growth. 1—3 leaf-scars of the preceding year; *Bs* scars of bud-scales of the terminal bud and *bs* those of axillary buds of the preceding year. Shoot above *Bs* the terminal shoot, and *I—III* axillary shoots of the present year.

maximum rapidity in early summer, and then slows down again towards the end of the growing season. Then the extended shoot goes to rest again, and its buds pass into

the winter stage of repose, to recommence the process in the following spring, with further elongation of the axis; or, in other cases, the apparent continuation of the axis

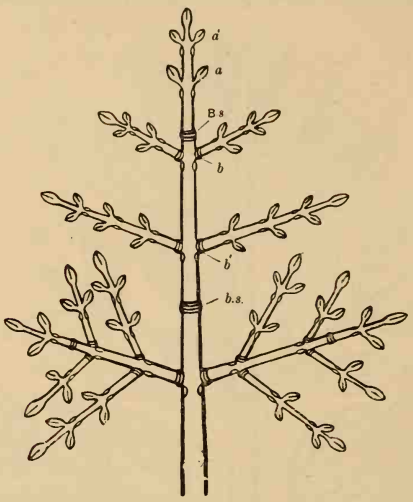


Fig. 47. Shoot such as that in Fig. 46 after casting its leaves and passing into the winter state. *Bs* scales of bud-scars at the base of current year's terminal growth; *bs* those at base of last year's growth; *b*, *b'* those at base of this year's lateral shoots.

may be effected by the shooting of the next axillary bud below the tip, the true terminal bud having died away.

True terminal buds continue the growth in

Pines	Firs	Larch
Cedars	Cypress	Yew
Arbor Vitæ	Maples	Sycamore.

But as a rule, the true terminal bud is aborted in

Birch	Aspen	Hazel
Elms	Willows	Lime
Prunus	Hornbeam	Poplars.

In the Beech and Oak the terminal bud is often aborted, but not always.

It is especially during the period of opening of the buds in May, or thereabouts, that we are able to readily verify the facts, already referred to, as to the morphological nature of the bud-scales, and the arrangement and folding of the young leaves in their interior, as is particularly clear in such cases as those illustrated in the series shown in Figs. 48 and 49.

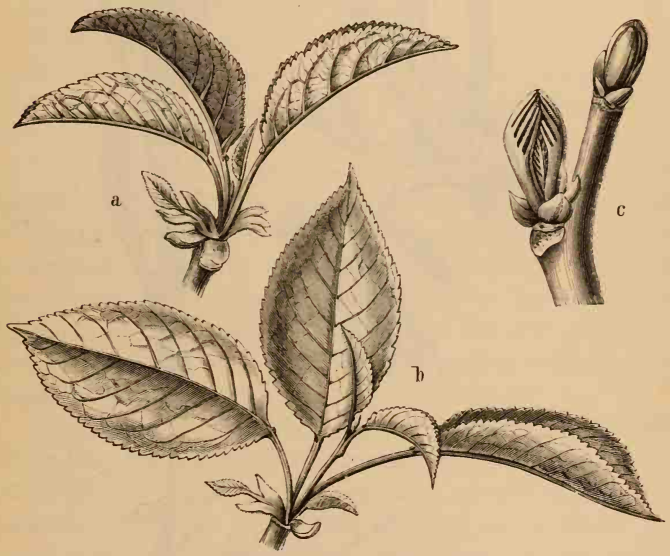


Fig. 48. *a* and *b* opening buds of Wild Cherry, *Prunus Avium*. The bud-scales are the bases of stipulate leaves, and the leaves conduplicate, all spirally arranged. *c* Walnut buds just bursting (K).

As long as the shoot developed from the bud is still growing, and for the remainder of the current season, the term *shoot* in the narrow sense may be conveniently

applied to it; but after the fall of its leaves in autumn—in the case of a deciduous plant which casts the leaves annually—or after the changes in texture and appearance

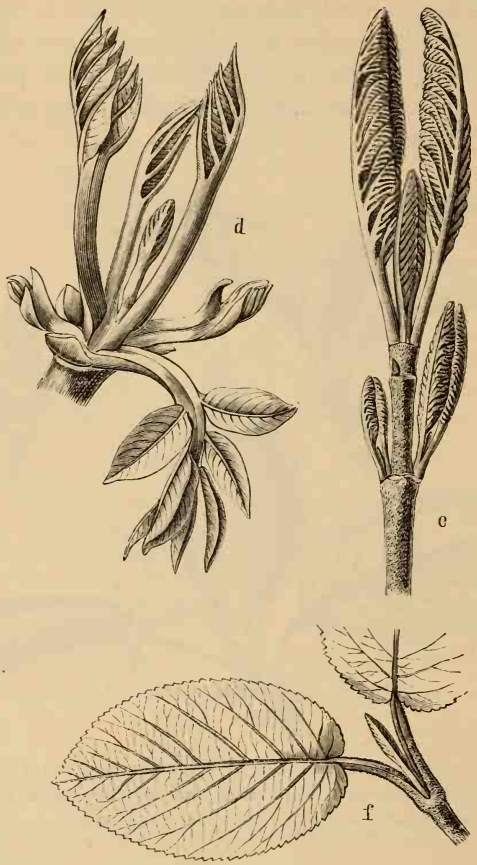


Fig. 49. *d* opening bud of *Juglans regia*, Walnut, showing conduplicate leaflets; *e* opening naked bud of Wayfaring Tree, *Viburnum Lantana*, showing plicate leaves; *f* fully expanded leaves of same (K).

consequent on the replacement of the epidermis by cork, the completion of its first year's wood, and other events comprised in the gardener's phrase "ripening of the wood," it is for many reasons useful to call the altered shoot a *twig*; later on the twig will become a branch, or, when large and of timber size, a limb.

The actual length attained in the annual growth by a shoot varies from a few millimetres to more than a metre, according to the species, the environment—good or bad soil, exposure to light, amount of water, temperature, &c. —and the age of the tree or shrub.

This is well shown by the leader, as the terminal shoot of the stem is called, of several of our trees. The rule is that the leader grows rapidly in its earlier years, and more and more slowly—i.e. adds a diminishing increment of length annually—as the tree reaches its maximum height. Measurements have shown that the leading shoot of the Larch during its second year may extend a foot or more, and in its third year one and a half foot, and so on for several years, rapidly growing up to its maximum height; while the leader of the Silver Fir will grow only one to three centimetres in the same period, and must be regarded as a slow grower.

The leader of a Spruce in my garden, in February, 1904, when the tree was twelve years old, was just over 70 cm. long—i.e. it had elongated to that extent during the past wet summer; while that of an Oak of about the same age had not extended more than 20 cm. or so, and that of a Beech less than 12 cm. during the same season.

It is stated that the rapidity of growth during early youth is related to the capacity of the tree to endure shade, and that the extensive growth of the Birch, Alder, Aspen, Ash and Scots Pine—all plants which endure shade

badly—enables them to rise rapidly out of the undergrowth into the light and air above.

The Silver Fir, Beech, Hornbeam, Lime and Spruce, on the contrary, are as a rule slow growers and can stand shade very well.

The case of the Spruce mentioned above, however, shows that other circumstances affect the matter, of which depth and quality of soil and amount of moisture are important.

Still, it is generally true that the growth of the leader of any tree in a suitable environment begins slowly, attains a maximum, and then puts on shorter and shorter seasonal lengths until it ceases, and some interesting cases are quoted by Hartig in illustration of this, as shown in the accompanying table.

Age	10	20	30	40	50	60	70	80	90	100	110	120	130
Species	Current annual growth in mm.												
Scots Pine	376	440	**534**	408	314	251	251	157	157	157	126	63	...
Spruce ...	188	459	**520**	451	459	289	232	173	170	119	50	...	...
Beech.....	282	**471**	376	376	376	345	157	126	126	110	78	63	3

Hence we have evidence that the maximum growth differs in value for each species, and occurs at different ages in each.

Büsgen gives the following as the maximum growths of the leader, according to the soil and situation, as well as the age of the tree.

Species	Maximum annual growth of leader	Year in which the maximum is attained
Scots Pine	17—52 cm.	15—30 year
Spruce	28—60 ,,	21—50 ,,
Silver Fir	24—50 ,,	20—85 ,,
Beech	30—65 ,,	25—45 ,,

But, apart from these annual length-increments of the whole shoot—and we must remember that all that applies to the leader is also generally true of each branch—it is necessary to realise that the rapidity and maximum length of growth of each internode along the shoot itself varies in quite a similar manner. I quote the following tabular statement from Büsgen. (See p. 74.)

This bears out the general rule that the nodes are close together at the base of the shoot, then become further and further apart as we ascend, and then approximate more and more as we approach the tip, where they are again close together; and since the length of the internode is an expression of the rapidity and energy of growth during the growing season, the two are correlated as already pointed out.

But, as the table quoted above shows, there may be variations—e.g. in the Norway Maple, where a second minimum occurs in the 9th and 10th internodes. Such may be due to the occurrence of cold dry winds, excessive sunshine and drought, and so forth, interrupting a temporary period of rapid growth.

Moreover, a shoot which has already passed through its period of normal growth, formed all its buds, and is preparing to cast its leaves and pass over into the con-

Species	Number of internode from base															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Hornbeam	2	4	10	18	25	36	40	**45**	**45**	35	30	34	34	30	25	15
,, ...	7	29	34	34	50	56	**65**	50	55	50	50	52	42	45	40	18
Oak	1	1	1	6	9	**18**	11	8	4							
,, ...	0·5	1	4	7	8	12	12	12	**17**	12	12·5	12	3			
Hawthorn	1	2	5	10	15	**19**	17	15	4							
Hazel	**75**	55	52	45	45	40	40	40	35	35	13	3				
Sambucus racemosa ...	5	10	20	**60**												
,, ,, ...	2	5	18	78	**145**	135	125	45								
,, ,, ...	3	10	35	85	**120**	95										
Bird Cherry	4	5	6	6	6	6	**7**	5	6·5	6·5						
Norway Maple	4	4·5	14	**19**	16	15	14·5	10·5	**4**	**2·5**	11	12	11	10	8	5

dition of a twig for its winter rest, is frequently again induced to start a second phase of elongation, by some change in the external environment. I have frequently seen this occur in the Oaks in Windsor Park, after being practically denuded of their foliage in summer by the attacks of a caterpillar which eats the leaves. The shoots at first tend to pass prematurely into the winter condition as twigs, but the persistent warm rains of early autumn induce the already formed buds to grow out into shoots and try again, as it were.

Such phenomena are periodically recurrent in some trees, e.g. the Beech, without any apparent cause such as that above referred to, and these second shoots during the rains after a dry summer and preceding an "Indian summer" are often termed Lammas Shoots. The causes of these second "breaks" of the shoots are obscure, and cannot be discussed here, further than to remark that they seem to be due partly to the excessive storage of reserve food-materials in the larger branches and the co-existence of conditions favourable to growth after a period of partial rest and drying out of the early matured shoots and buds. The second flowering of Horse-chestnuts and other trees is doubtless a phenomenon of the same kind.

CHAPTER X.

DIFFERENT KINDS OF SHOOTS.

Coexistence of long and dwarf-shoots—Spurs of the Pines—Variations in development—Beech—Effects on the branching—Trees with marked development of dwarf-shoots—Transitions—Spurs, flowers and thorns.

Our study of the bud at rest, and of the developing shoot, has shown that the latter elongates by the growth of its successive segments, or internodes, at different rates in different parts of the shoot; we have also seen that some buds give rise to leafy shoots only, others to flowering shoots and so on. But even in the leafy shoots of one and the same parent axis, we find considerable differences in the growth of the young shoots as they emerge from the bud.

In some cases the shoots extend most of their internodes rapidly, and develop into "Long shoots" such as the leaders we have referred to above; but in other cases the shoot, although it may possess quite as many internodes as the long shoot, only elongates just sufficiently to enable the leaves to expand, and these "Dwarf-shoots" or "Spurs" appear to have hardly any differences between node and internode at all, the leaf-insertions being so closely crowded that the leaves are in rosettes.

Striking examples of the coexistence of these dwarf-

shoots and long shoots are afforded by many of our native and cultivated trees and shrubs, e.g. the Larch, Cedar, and Barberry, where the crowded tassels or rosettes of leaves forming the dwarf-shoots are in the strongest contrast to the thin long shoots of the same plant, which have their leaves separated by considerable stretches of internodes.

In the Pines, again, the numerous dwarf-shoots or "spurs" stand in sharp contrast to the far fewer long shoots on which they are borne; each bears two, three or five thin green leaves (needles) with a few scale-leaves at its base, all devoid of perceptible internodes, and opening from the axil of a scale-leaf on the parent axis on which the extension of the internodes is evident, as already described on p. 18.

But our ordinary trees show the same state of affairs, with very few exceptions. If we examine one of the stronger sprays of foliage of a Beech in autumn, just after the leaves have fallen, and at the end of the seasonal growth, it will be seen that the development of the shoots from the buds which opened last spring varies considerably in the different regions of the twig bearing them. In a case selected (Fig. 50), a bud had grown out to a long shoot measuring several centimetres, on which other axillary buds developed as usual (*A*—*B*), and two of the uppermost buds on this shoot (*C* and *D*) developed further into long shoots, bearing buds even during the then current season; but buds lower down, though they did begin to develop shoots, produced nothing further than the beginnings of short outgrowths (dwarf-shoots), on which a few leaves, without axillary buds or elongated internodes, were formed (Fig. 50, *E*), while the two lowermost buds were merely formed and did not commence any further growth that season.

But now let us compare the development of the bud next below *B* on the same twig. While the bud just referred to elongated to the long shoot *A*—*B*, on which

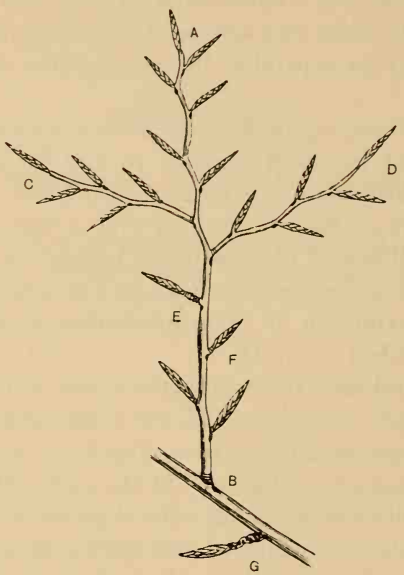


Fig. 50. A twig of Beech. *A* the apex of the preceding year's growth into a long shoot; *B* bud-scale scars at its base. It bears buds such as *F* in the axils of the now fallen leaves, two of which had already grown out into long shoots *C* and *D* before the winter rest, and one, *E*, into a dwarf-shoot. *G* a dwarf-shoot developed during the same season as the long shoot *A*—*B*.

at least 11 leaves, separated by long internodes were borne—as indicated by the leaf-scars beneath the buds or shoots, from *B* to *A*—each bearing a bud, or eventually a long (*C*, *D*) or short (*E*) shoot in its own axil, the bud we are now considering has only the short stretch from the parent twig to the base of its terminal bud, indicated at *G* (Fig. 50), to show as the result of its seasonal growth

—i.e. while the bud at *B* developed the long shoot *A*—*B*, the bud at *G* only gave rise to a short shoot or dwarf-shoot indicated in the figure.

But close examination shows that on this dwarf-shoot *G*, there were borne during the season several leaves—it may well be quite as many as on the long shoot *A*—*B* but closely crowded owing to the non-development of the internodes. This, again, is evident from the leaf-scars.

It is important to notice that in future years, while *A*—*B*, as also *C* and *D*, may go on developing equally extended long shoots, *G* may all the time only extend annually at the tip by about the same amount as it did last season. On the other hand *G* may at any time alter its rate of growth and develop into a long shoot; or *A*—*B*, or any of the buds or shoots on it may for one year, or even for several in succession, develop as a dwarf-shoot.

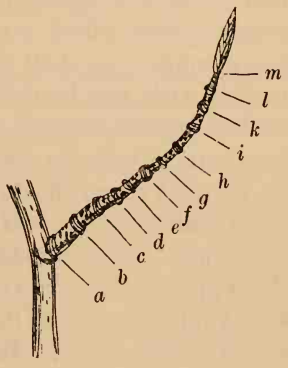


Fig. 51. Dwarf-shoot of a Beech. The letters *a*—*m* point to the bud-scale scars of successive years, so that the shoot is 11 years old. Below *a* is visible the scar of a leaf from the axil of which the bud originated; above *m* is the terminal bud of this year. Between each set of bud-scale scars are the crowded scars of fallen leaves.

As an illustration of a dwarf-shoot which has persistently developed as such, we may take Fig. 51, in which each of the intervals from *a* to *b*, *b* to *c*, *c* to *d* and so on indicates the growth of one year, whence we infer that the whole shoot (*a* to *m* in the figure) has taken 11 years to attain its present length of a few centimetres—say 7 cm., since the length of a well-developed Beech-bud, such as that terminating this shoot, is about 2 cm.

It may be noted that the lines *a*, *b*, *c*, &c., point to the groups of scars left by the fallen bud-scales of each year: the small rounder scars on the intervals representing the annual growth, being those of the fallen leaves. The curved black line below the line *a* represents the scar left on the fall of the leaf of 11 years ago, which leaf bore in its axil the bud that has since developed into the dwarf-shoot *a*—*m*.

It will be evident from these studies that the varying development of long shoots and dwarf-shoots lays the foundation for much variety in the formation of the branch-system which results as they pass into advanced age, a subject we shall deal with more in detail in connection with the branching of the tree.

Different trees and shrubs differ much in respect of the contrast between dwarf-shoots and long shoots.

Distinct dwarf-shoots are found on the following:—

Beech	Hornbeam	Barberry
Ling	Larch	Cedar
Pine	Ginkgo	Ash
Apple	Pear	Plum
Almond	Blackthorn	Bird Cherry
Rhamnus	*Cratægus*	Laburnum.

In the following the distinctions between dwarf-shoots and long shoots are gradual:—

Elms	Poplars	Lime
Birch	Hazel.	

In the following the dwarf-shoots, apart from the flowering shoots, are practically indistinguishable from the long shoots:—

Willows *Sarothamnus.*

But, as we shall see later, the dwarf-shoots of some trees and shrubs are eventually rendered even more distinct than usual by being the bearers of flowers and fruit, or by their ends being transformed into thorns, as occurs in many of our fruit trees.

CHAPTER XI.

TEGUMENTARY SYSTEM—EPIDERMIS.

Persistence and thickness of epidermis—Cuticle—Functional importance—Mucilage, wax, resin, &c.—Structure of epidermis—Cell-contents—Outgrowths of epidermis—Hairs—Glands—Emergences—Prickles, &c.

WITH the exception of some cases reserved for discussion later, the whole of the shoot-system of a higher plant, at any rate while young, is covered by a layer of cells known as the epidermis. In the typical case, as exemplified by herbaceous stems, leaves, shoots of trees and shrubs, and all the parts of flowers, this epidermis originates in the same way and is one cell thick; but in the cases departing from the type, after-changes bring it about that the epidermis is composed of more than a single layer of cells, or the layer which acts physiologically as an epidermal covering has a different origin from the true epidermis, and is therefore something morphologically different.

These cases, again, have to be distinguished from those where the true epidermis is eventually cast off, and other coverings provide the protection hitherto fulfilled by that layer, as occurs sooner or later in most twigs and branches and other perennial organs of higher plants.

The typical epidermis is seen in magnified sections through most ordinary herbaceous stems of seedlings or annuals, or the current year's shoot of perennial plants, as well as those of leaves, sepals, petals, anthers, carpels, &c., as the outermost continuous layer of cells, fitting together without intercellular spaces (excepting at certain definite spots where the *stomata* occur: organs with which we shall be concerned in a later volume), more or less rectangular in section, and with the outermost walls thicker than those inside. If stripped or shaved off, and viewed from the outside, the shapes of the cells vary according to the plant or organ examined, giving characteristic appearances; on the shoots of Dicotyledons, for instance, the cells are usually elongated in the direction of the long axis of the organ, whereas on the leaves the cells are commonly irregular with sinuous boundary walls. In the former case the general shape of each cell is more or less prismatic, in the second tabloid.

The peculiarities of the outermost walls of the epidermal cells give us the clue to the primary functions of the layer, which are, to mark off what belongs to the plant from what is the environment, and to prevent indiscriminate exchanges of gases and vapours between the two.

This is best illustrated by what occurs in the parts of land-plants exposed to the air with its rapidly varying conditions.

The outermost cell-walls of the epidermis of a leaf, for instance, not only form a continuous coat over the whole organ, but the external layers of such cell-walls are extremely impervious to water and gases, owing to their being more or less altered in chemical and physical properties by the formation of cutin or cork-substance in them: this altered layer is known as the *Cuticle*, and the parts

of the cell-walls composing it are said to be *cuticularised*. Owing to the resistance of the cutin to even strong sulphuric acid, which rapidly dissolves the rest of the cell-walls, the cuticle can be stripped off as a thin, continuous and very elastic, tough membrane if the epidermis and other parts of the leaf are treated with this reagent.

That the functions of the cuticle are protective, and especially so against the loss of water from the underlying cells, is evident on comparing various plants or parts of plants with reference to their conditions of life. Thus, we find the cuticle especially thick and well-developed on plants like Cactuses, Aloes, Yuccas, Cactus-like Euphorbias, and other forms adapted to life in arid regions or other situations where it is advantageous that the water in the tissues should not escape too easily. In many such cases the very thick outer walls of the epidermis not only show a well-developed cuticle, but the layers of cell-wall immediately beneath are also altered subsequently from the condition of cellulose. These layers are not cuticularised, however, and in some thin cell-walls they are converted into more or less slimy or mucilaginous substances, and in some cases this goes so far that the swollen viscid substances burst the cuticle and flood the part concerned as with an ooze. This is particularly the case with certain buds and inflorescences, where the viscid layers serve to protect the young organs from insects, or, in some cases, against over-evaporation, or water, or changes of temperature as stated on p. 57.

The cuticle of many plants is rendered still more effective as a protection by the deposition of wax: this is very commonly the case where protection against soakage by water is an advantage. The "bloom" on certain shoots and twigs, e.g. Raspberry, *Salix daphnoides*, and on Plums and Grapes, Cabbage and Lotus-leaves, &c.

is a good example, where the wax is so abundant that it is excreted on to the surface in the form of granules, or of rodlets perpendicular to the surface, and forms a layer which can be rubbed off with the fingers. If organs of this kind are plunged into water while the wax layer is intact, they are not wetted, but glisten as if covered with silver, owing to the layer of air entangled between the water and the wax; and if rain-drops fall on the surface they roll off at once with a silver reflexion suggesting the utility of the bloom for preventing lodgement over the stomata. That the waxy bloom is also a protection against parasitic fungi is also a tenable hypothesis. In some cases, such as the nodes of the Sugar Cane and other Grasses, the leaves and stems of some Palms (*Ceroxylon klopstockia*), various fruits (*Myrica cerifera*), &c., the wax layers are several millimetres thick and can be utilized in commerce by scraping off and separating the wax in hot water.

In other cases fatty or resin-like substances are secreted in the cuticle—e.g. leaves of *Gymnogramme*, and certain viscid buds to be referred to below.

The epidermis itself presents all the ordinary features of a cell-tissue, and its cell-walls and contents may show all the peculiarities of those of typical cells. Nevertheless, in the majority of cases certain characters of general application are to be noticed, as follows. As a rule the epidermal cells only divide by walls perpendicular to the surface of the young organ, and consequently the layer is only one cell thick: exceptions are not common, but they do occur—e.g. Mistletoe, *Ficus*, *Begonia*, and others.

Again, the rule is that the ordinary epidermis-cells, although living and provided with normal protoplasmic contents and nuclei, do not contain chlorophyll-corpuscles: the exceptions chiefly concern certain shade-

loving plants like Ferns, Begonias, and some others. It must not be concluded that this is due to direct light-reactions, however, for the chloroplasts are present as colourless bodies around the nuclei, and in the guard-cells of the *stomata* they attain their normal size and green colour, even in the cases where they are lacking in the ordinary epidermal cells.

But although the cells rarely contain chlorophyll, and are often quite colourless, it commonly happens that their cell-sap is coloured red, more rarely blue or other colours, and in many cases at least there can be no doubt that the red sap serves as a screen against too intense illumination, or as an absorbent of certain rays of light used for special purposes—e.g. the frequent red colouring of many young foliage leaves and shoots—while the blues and other colours in the epidermis of petals are of use to attract insects.

Various other substances, such as tannins, soluble starch, &c., may also occur in the epidermis.

Hairs of various kinds play such important parts in the biology of plants that we may well regard them as a distinct category of organs.

A typical hair is an outgrowth of a single superficial cell, and, in aërial organs of the higher plants, of a cell of the epidermis. This definition, though it covers the morphological idea of what a typical hair really is, must not be pushed too far however, for hairs may arise from other than epidermal cells (e.g. Root-hairs, the hairs on Fern-prothallia), and more than one cell may be concerned in their origin: moreover, it is impossible to distinguish sharply between hairs and exactly similar organs in certain lower plants which receive different names. Finally, hairs may be formed internally in the body of a plant—e.g. in the lacunæ of some Water-Lilies and Aroids.

Nevertheless, in the typical case a hair results from the bulging out of a single epidermal cell, the protuberance then growing forward as a closed tube, which

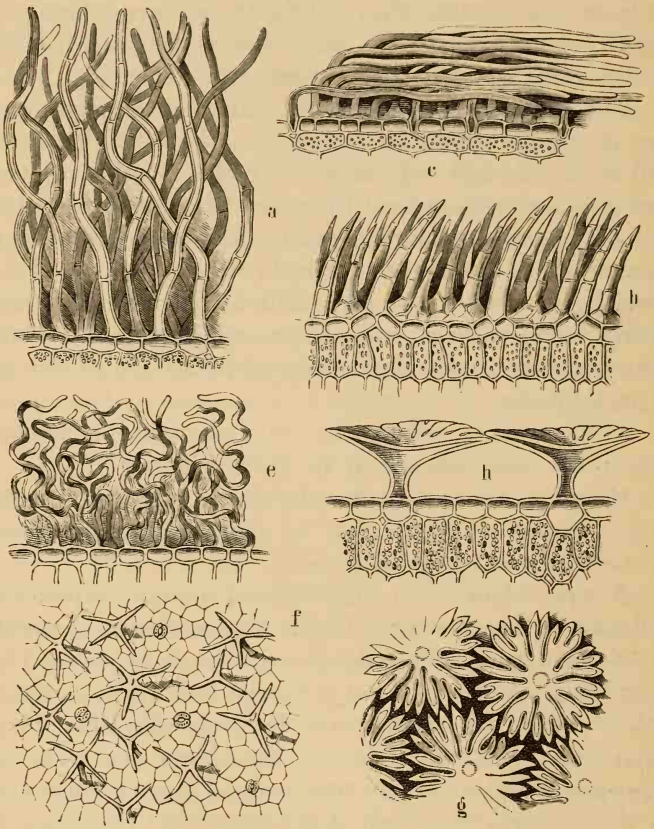


Fig. 52. Types of hairs. *a* woolly hairs of *Gnaphalium*; *c* silky hairs of *Convolvulus*; *b* velvety hairs of *Gloxinia*; *e* woolly hairs of *Centaurea*; *f* stellate hairs of *Alyssum*; *g* stellate stalked scales of *Koniga*; *h* the same in section.

may remain unicellular or become divided up into cells by partition walls.

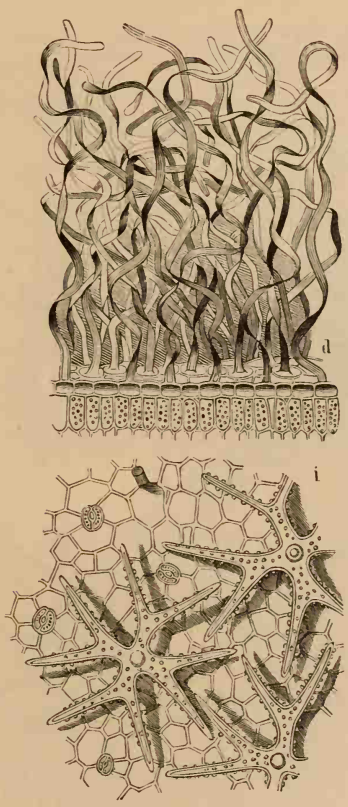


Fig. 53. *d* woolly hairs of *Gnaphalium*; *i* stellate hairs of *Draba* (K).

The principal forms of hairs, considered as individual organs, are as follows. The unicellular fine hairs, so common on leaves and herbaceous stems, are described as silky (*Salix alba, Laburnum*) when bent down and

appressed to the surface (Fig. 52, *c*); velvety or pilose (Apple, *Salix viminalis*) when short, close, and erect,

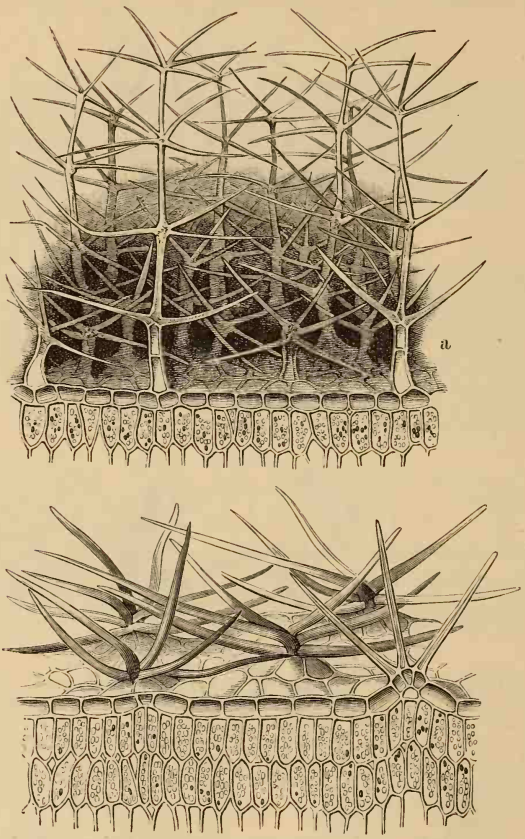


Fig. 54. Types of hairs. *a* branched tomentose hairs of *Verbascum*; *b* tufted tomentose hairs of *Potentilla*.

like the pile of velvet (Fig. 52, *b*); shaggy (villose) when long and loose; woolly (tomentose) when still longer and

looser (Fig. 52, *a*, *e*), and such hairs are often flattened in section (e.g. *White Poplar*), and so forth.

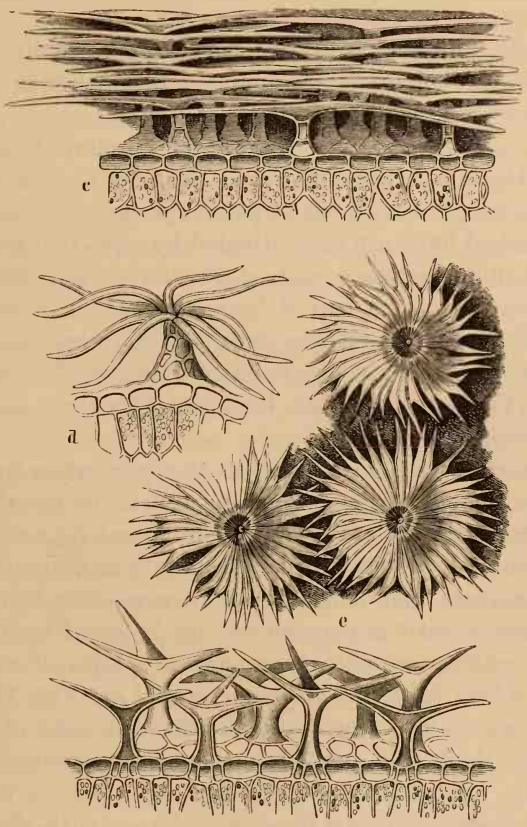


Fig. 55. *c* T-shaped silky hairs of *Artemisia*; *d* stellate hairs of *Correa*; *e* stellate scales of *Elæagnus*; *f* stellate hairs of *Aubretia* (K).

Multicellular hairs may have the septa only across the long axis of the hair, and the latter is then said to be

jointed (*Tradescantia*): such hairs may also be silky, velvety, woolly, &c. as before. Silky hairs are also often met with in the shape of a T with a short stem, as in many species of Scabious, *Aster*, *Artemisia*, where the upper cell of the series grows out in two opposite directions (Fig. 55, *c*): such hairs are common in Cruciferæ, where the hairs are also often stellate, or forked, owing to the transverse growth occurring in three or more directions —e.g. *Alyssum*, *Aubretia*, *Draba* (Fig. 52, *f*). In other cases the outgrowths occur as peltate scales.

Branched hairs are often divided by septa in directions perpendicular to those referred to above, and we have then forms such as tufted hairs (*Potentilla*, *Cistaceæ*), scales (*Hippophaë* and *Elæagnaceæ*), the furfuraceous hairs of Bromelias, the stellate hairs of *Phlomis*, *Verbascum*, *Correa* (Fig. 55, *d*), or the branched flocculent hairs of *Verbascum*, and so on.

In most of the cases referred to, the hairs, when mature, have lost their living contents, and consist of merely the cell-walls filled with air, and their functions are principally those of protection against unduly rapid variations of temperature and moisture: they cover the leaves or other organs with a non-conducting layer of entangled air and cellulose which acts exactly as a layer of cotton-wool (the long hairs of *Gossypium*) would do (Fig. 53, *d*).

In very many cases, however, the cell-walls of such hairs are thickened and strengthened in various ways, either by mere thickening of the cell-walls, as in the *bristles* or *setæ* of many *Borragineæ*, &c., or with deposits of silica (*Urtica*, *Bœhmeria*), calcium carbonate (many *Borragineæ*).

In another large class of cases, however, the hairs preserve their living contents, and their functions often depend especially on the continued activity of these.

Many such hairs are known as glandular hairs, owing to their excreting substances of a viscid or resinous, and often odoriferous, nature, or with other peculiarities.

In the simplest forms of glandular hairs, the unicellular hair undergoes changes in the layers of cell-wall immediately beneath its thin cuticle, such that the cellulose is altered and softened, and excreta of the nature of gums, resins, ethereal oils, or mixtures of these accumulate and eventually burst the distended cuticle, and smear the ruptured surface; or the excreta accumulate in the cell-cavity itself and burst the walls. Such viscid hairs (colleters) are very common on young leaves and inflorescences in winter buds, the resinous and balsamic secretions smearing the surfaces of the immature organs and serving as non-conducting protections against the effects of low temperatures and damp, e.g. in the Horse-chestnut, as described on p. 15.

Glandular hairs of this nature are also common on mature flower-buds and inflorescences of Saxifragaceæ, Primulaceæ, Caryophyllaceæ, Labiatæ, Compositæ, &c., where they are often of protective use against small marauding insects. In very many cases these glandular hairs are *capitate*, i.e. the one or more cells forming the stalk of the hair end in a rounded dilated head of one or more cells, and the secretion is formed in the latter. Such capitate hairs are well seen on young twigs of Hazel, inflorescences of *Saxifraga, Primula,* &c.

In the Hop some of the hairs have their heads dilated in a peltate manner, and secrete the bitter *Lupulin* in their cell-walls.

Vesicular or thin-walled bladder-like hairs, filled with water, are common on some *Piperaceæ*, Begonias, *Urticaceæ, Ampelideæ*, &c., and have to do with the temporary

storage of water. In some cases they only occur on quite young leaves.

So far I have regarded hairs, whether unicellular or multicellular eventually, as derived from a single (or rarely more than one) superficial cell. The case is not essentially altered when, as often happens, more than one cell of the epidermis takes part in the initiation of the multicellular outgrowth, and cells of the sub-epidermal tissues also enter into its composition.

Morphologists distinguish such composite outgrowths as *Emergences*, from the true Hairs or *Trichomes* hitherto considered: as before, the cells may lose their living contents or not, have their cell-walls thickened, exude excretions, and so on.

One of the simplest forms of emergence is found in the glands at the margins of the stipules of the Pansy (*Viola tricolor*), where an axial row of thin-walled sub-epidermal cells emerges and is capped by the enlarged secreting epidermal cells.

More remarkable are the *Tentacles* of various insectivorous plants (e.g. *Drosera*) where all the tissues enter into its structure. The cells at the upper end secrete a viscid slime at the surface, and after an insect has become entangled in this, the tentacle secretes digestive juices from its cells, and eventually absorbs the peptonised proteids. Similar digestive and absorptive functions appertain to true hairs in the case of other plants (e.g. *Pinguicula, Utricularia, Nepenthes*, &c.), but since we are not here concerned with this interesting biologic group of plants, I pass them by with this mere reference.

Prickles, which must be distinguished from *Thorns*, are either emergences (Rose, Gooseberry) or multicellular hairs of pointed form and with the cell-walls hardened and dry. Similar structures are common on fruits or

their coverings—e.g. *Æsculus, Datura, Ricinus,* Oaks and Beeches, some Palms.

Among the most remarkable and beautifully adapted emergences may be mentioned the *Pappus* of the Compositæ, the hair-like forms of which admirably serve their purpose of wind distributors. True hairs are often formed subserving the same purpose on seeds (Willows, Poplars, Asclepiadeæ, *Gossypium, Eriodendron,* &c.) or on fruits (*Stipa, Aristida, Eriophorum,* &c.).

CHAPTER XII.

TEGUMENTARY SYSTEM—*continued.*

CORK—PERIDERM.

Persistent epidermis—Replacement by cork—Origin of periderm—Superficial periderms—Deep-seated periderms—Lenticels—Bark—Smooth and rough barks.

One of the striking differences between trees, shrubs and other woody plants, as contrasted with herbs, depends on the formation of corky or other coverings on the older twigs, branches and stems, to replace the delicate epidermis which is always found on the young green shoots. In very few cases do we find the true epidermis persist beyond a few months on the twigs, though in these exceptional instances —e.g. Yew, Spindle Tree (*Euonymus*), *Aristolochia Clematitis*, *Acer Negundo* and the Mistletoe—it goes on growing for from two to several years as the twig thickens.

In the vast majority of cases, on the contrary, the epidermis ceases to grow towards the end of the first summer, and is to be seen at the base of the twigs dying and cracking and peeling off under the tension exerted by the thickening tissues beneath, and it is this dead papery flaking epidermis, exposing the layers beneath, which initiates the changes in smoothness and colour from green to grey, brown, &c. on the older twigs, of which

Currants, Birches, Cherries, Hazel, Elms, Limes, Poplars, &c. furnish excellent examples.

As the epidermis cracks and dies, under the pressure exerted by the thin layer of cork which is formed to replace it, a tougher and more water-tight, elastic and resistant covering to the delicate cortical tissues beneath results; and since this cork is usually of some shade of pale brown or grey, its hue, visible through the epidermis, or exposed by the fissures, adds its effect in replacing the green tint of the young shoot which prevailed hitherto, and which was owing to the green chlorophyll of the cortex shining through the translucent young epidermis.

In by far the larger number of our trees the cork-layer begins to form in the layer of cortical cells immediately beneath the epidermis itself—e.g.

Abies	Birch	Alder
Hazel	Beech	Oak
Hornbeam	Chestnut	Elm
Plane	Poplars	Elder
Horse-chestnut	Lime	*Rhamnus*
Prunus	*Viburnum Opulus*	*Cornus mas.*

In these cases the growth of the cells in the radial direction is followed by a number of divisions parallel to the surface of the epidermis: the more superficial of the daughter-cells thus formed become transformed into cork, while those lying deeper either carry on the growth and divisions, resulting in the development of more cork-cells, or, in addition, add also to the cortical cells beneath.

In this way is gradually produced a layer of cork (Periderm), varying in thickness according to the species and to the length of the period of growth of the cork-forming cells: this layer forms an elastic covering to the cortex and comes more and more completely to the surface as the true epidermis is sloughed off.

In Roses, Apples, Pears, Willows, *Viburnum Lantana* and some others, the cork is traced to a different origin, in so far that the first divisions take place in the epidermal cells themselves, so that the primary cork-layer is from the first superficial, instead of having to push off the dead epidermis proper before becoming so.

In Pines, Larch, *Ribes*, *Robinia*, Honeysuckle, *Berberis*, *Philadelphus*, *Spiræa*, &c., on the other hand, the first cell-divisions resulting in cork-formation take place more or less deep down in the cortex; so that when the first cork-layer is completed—since it is always impervious to water—it excludes from any further participation in water-supplies and food-materials from within, all those cells which lie to its outer side. Consequently all the cortical cells on its exterior, as well as the splitting and dying epidermis cells, die and are soon sloughed off.

The depth in the cortex at which this cork-layer (periderm) may begin to form varies in different species. In some, indeed, e.g. Yew, Heaths, Vine, &c., it may lie so deep that the region of the vascular bundles themselves is invaded, and practically all the cortical tissues may be starved to death and sloughed off.

All these tissues cut out by the periderm, and consequently deprived of water and food-supplies from within, die and shrivel up as more or less brown or grey or otherwise dull coloured débris, and the totality of them is termed Bark.

An interesting phenomenon in connection with the replacement of the epidermis by periderm is the formation of the cork-warts, or *Lenticels*, so prominent on branches of Elder, *Robinia*, *Rhamnus*, Alder, Walnut, *Pyrus*, Poplars, *Prunus*, Chestnut, Maples, Pear, *Myrica*, Horse-chestnut, and more or less so in all European trees and shrubs except *Clematis*, the Vine, *Philadelphus coronarius*, *Rubus*

odoratus, and perhaps one or two others; and even in these latter cases there are fine intercellular spaces in the periderm-layers over the ends of the medullary rays, which represent lenticels in function, in that they permit a slow interchange of gases with the exterior.

For the lenticels are nothing more than spots in the periderm where the cork-cells become loosened and separated sufficiently to allow transpiration and the free passage of air to and from the exterior—they replace in fact the stomata of the epidermis, and are frequently formed below them. As a rule they are blocked up during the winter by the most recently formed periderm-layer, and are forced open in spring, when the loose powdery cork-cells often protrude so evidently as to give rise to the name cork-warts.

Excellent diagnostic characteristics are afforded by the abundance, prominence, size and shape—e.g. elongated longitudinally or transversely—and the colour contrasts of these lenticels on the younger branches, &c.

The tissues resulting from the activity of the cork-cambium are, with the latter, included in the term periderm, and it is clear from the foregoing account that the periderm may be superficial or deep-seated in origin.

But in many trees, while the first formed periderm is superficial (except for the rapidly sloughing epidermis) and remains so for years by continued activity of the cork-cambium which keeps pace with the thickening of the branch—e.g. Beech, Hornbeam, Hazel, Barberry, Privet, *Ailanthus*, Birch, &c.—matters are complicated in others by the death of the first superficial periderm after the first year, and the repeated formation of more deeply situated new periderms year by year.

These latter cases, therefore, are after the first year comparable to those mentioned above, where the peri-

derm is deeply situated from the first, and a new set of events supervenes owing to the fact that the surface of the branch is now covered by something more than true periderm; namely by all those parts of the original cortex which have been cut out by the most deeply situated cork-cambium as well as its own cork-layer.

Bearing in mind that, owing to the water-tight nature of this cork everything outside it dies, we recognise that the covering thus produced consists of various kinds of dead cells derived from the cortex, the outer periderms, and, in the case of very deeply situated periderm, of parts of the inner cortex, phloem, &c. This congeries of dead tissues cut out by the deepest cork-cambium is known as Bark, and, as we have seen, it may be a relatively simple or a very complex mass of layers. Moreover, even when it consists for the most part of cork only, which is an extensible and elastic tissue, the continued growth in length and thickness of the twig or branch soon brings about its rupture, especially by means of longitudinal fissures, but also, and particularly in those cases where it is developed at an early period on young twigs, by transverse cracks; and as the pressure of the enlarging branch extends these fissures and cracks, the older bark peels or flakes or strips off in successive layers, patches or strips, and exposes newer periderms or bark lying deeper in the tissues. The latter then subsequently suffers a similar fate.

It is owing to these phenomena that the very various characteristics of bark, in the widest sense, are due. Strictly speaking the perennially renewed epidermis of the Mistletoe, and the superficial periderm of Beech, Hornbeam, Hazel, Birch, Barberry, Privet, *Ailanthus*, are not true bark, though such may be formed after many years—i.e. on old stems—as deeper periderms are

developed. In the majority of cases, however, true bark is developed very early, or even during the first year, especially when, as in Pines, Larch, *Ribes*, *Robinia*, Yew, Vine, &c., the first formed periderm lies deep in the cortex. In practice, however, it is not the custom to emphasize these distinctions of the tegumentary system, and foresters are in the habit of speaking of smooth or rough, thin or thick barks, &c., without reference to the mode of origin, a looseness of terminology which leads to difficulties which we shall endeavour to clear up when discussing the subject of branches and the trunks of older trees.

We are now in a position to understand the principal characters observable on the twigs, branches and stems of various ages of trees and shrubs, and may summarize them under the following heads.

The colour, smoothness and other characters of the surface of the youngest twigs depend on the properties and persistence of the epidermis; the similar features of one-year-old twigs and the younger branches, on the colour of the periderm, its thickness and abundance, its persistence, and its superficial or deeper situation, as well as on the shape, size and abundance of lenticels.

The peculiarities of older branches and stems depend on the presence or absence of periderm or of bark; the colour, roughness, hardness, thickness and especially the mode of breaking up or scaling or peeling off of the latter; the formation of ring-bark, scales or tabular areas, crevasses, splitting into fibres, &c., subjects to be dealt with in detail in a later volume.

CHAPTER XIII.

LEAF-CASTING AND THE FORMATION OF LEAF-SCARS.

Relations of leaf to shoot-axis—Venation—Fibres and vessels—Continuity of the vascular system—Fibro-vascular skeleton—Comparison to girders, water-supply and drainage systems—Fall of leaves—Separation-layer or absciss-layer—Leaf-scar.

THE study of the leaf as a physiological organ of the plant will be deferred for another section of this work, but it is necessary at this stage to emphasize some aspects of the relations between the shoot-axis and the leaves borne on it, in order the better to understand certain marks on the twigs in their winter condition.

Our examination of the bud has shown us that the leaves are outgrowths of the axis, and that as the axis elongates the leaves also grow longer and broader. When the leaf is completed we notice that it is in typical, that is to say ordinary cases, a flattened sheet of green tissue with harder parts running in its substance in the form of much branched networks, termed the venation of the leaf (Figs. 19, 26, 48 and 49).

This venation consists essentially of numerous very thin pipes or tubes employed for conducting fluids from one part of the leaf to another, and called vessels; and of

equally numerous strands of stiffer, elastic, thread-like supporting structures called fibres.

The fibres contribute to the office of keeping the thin and often delicate lamina or blade of the leaf—i.e. the flattened sheet of green tissue—expanded flat in the light and air, somewhat as the ribs of an umbrella keep the silk stretched; while the vessels conduct liquids, as said, from one part of the leaf to another.

In the stalk or petiole of the leaf these vessels and fibres are gathered together in one, three, or five or more strands and pass through the leaf-insertion into a node, where they pass down into the axis of the shoot, and join in the internodes with other strands coming from other leaves and passing similarly down the internodes.

Hence we say that the venation of the leaf is composed of bundles of fibres and vessels—shortly termed fibro-vascular bundles, or even more shortly vascular bundles—which branch out more and more into a meshwork in the lamina, and are gathered into strands, or groups of such bundles, in the petiole, to again branch out in the shoot-axis and join on to strands of vascular bundles in the internodes. This continuity of the fibres and vessels is especially important because it facilitates the passage of water and other fluids from shoot-axis to leaf and *vice versâ*, and at the same time provides for the support and rigidity of the leaf on the shoot-axis, a matter of peculiar significance in view of the buffeting which leaves undergo in a high wind.

But the arrangement of the fibres and vessels of the bundles in the shoot-axis is also by no means devoid of order, as will be seen by referring to Fig. 56, which represents a skeleton view of these strands in a particular plant. This skeleton is obtained by removing all the softer tissues which cover up the shoot shown in *a*, and fill

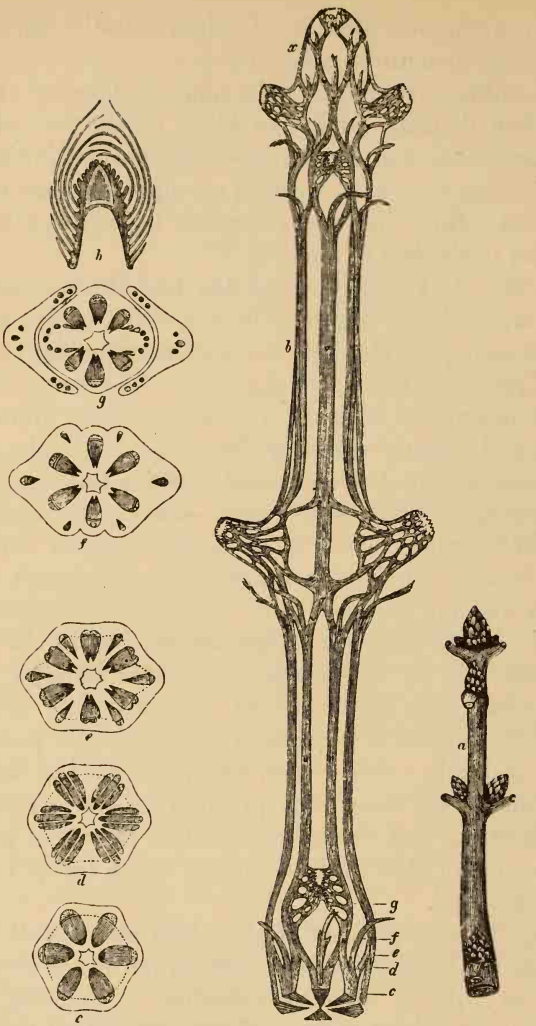


Fig. 56. Vascular anatomy of a shoot (*Atragene*). *a* the shoot before dissection; *b* the same enlarged and with all the soft tissues removed, showing the woody skeleton; *c* section across the internode at *b* or *c*; *d* section at *d*; *e*, *f*, and *g* sections at *e*, *f*, and *g* respectively; *h* the terminal bud, above *x*, in longitudinal section (Ha).

up the central and intervening parts; just as skeletons of leaves can be obtained by rotting away the softer tissues of the leaf-blade, and leaving only the harder fibres and vessels of the venation.

We are not here concerned with the differences in detail, met with in different plants, as to the exact course pursued by the different vascular bundles in the leaf, or in its petiole, or in the shoot-axis; nor are we concerned with the differences met with in the proportion of fibres to vessels, or the kinds of vessels themselves, or of other tubular or supporting structures in the vascular bundles. Our object is simply to emphasize certain matters of fundamental importance common to all cases, and the first of these is the complete continuity of all the structures referred to not only as between shoot-axis and leaf, but also as between shoot-axis and other parts, buds, branches, and even the root and its branches.

Every part of the vascular system of the plant is in continuity, so that fluids entering the root can be brought up to the highest shoot or leaf, and fluids from the latter can pass from leaf to shoot-axis and to any branch or bud or root in communication with the leaves by these minute pipes, the vessels. We may compare the whole fibrous system to a system of engineer's girders, struts and columns; and the whole vascular system to a complex network of water-pipes and drains, which for purposes of convenience and economy accompany the supporting columns, struts and girders all over the plant. These matters will occupy our attention further in another section of the work.

At present we are concerned more particularly with the question of continuity between leaf and shoot-axis.

When the leaf has finished its life's work, it may be—and generally is in the trees and shrubs here dealt with—at the end of the autumn of the first year, or, in so-called

evergreens, after two or three or more years, the leaf falls (Fig. 57). Now this falling of the leaf is as truly a regular

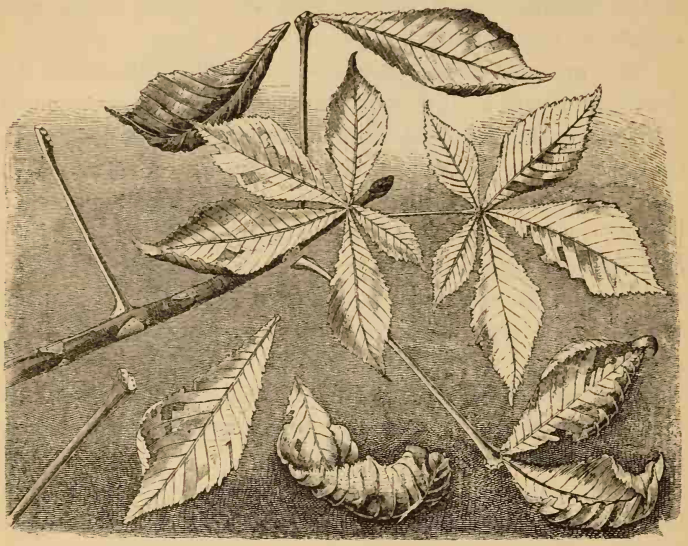


Fig. 57. Fall of leaves of the Horse-chestnut in autumn. Each leaflet disarticulates from the common leaf-stalk, and the place on the stem where the latter was articulated remains as a scar, as in Fig. 18 (K).

biological phenomenon as any other phase of the plant's life, and is as carefully prepared for as is, for instance, the formation of a bud.

Just before the fall of the leaf a plate of tissue is formed across the base of the leaf-stalk where it is inserted on the shoot. This plate of tissue is shown in section at *Ab* in Figure 58, and it will be seen that it runs right across the leaf-stalk, traversing the vascular strands (*st'*) just above the line indicated by the letters *Ab*. Underneath the epidermis (*e, e*) a layer of cork-tissue (*p, p*) has been formed, and this affords a better protection to the

layers beneath than the now dying epidermis could do; and we notice that this layer of cork-tissue also stretches across the base of the leaf-stalk (p') as a plate parallel to the plate of tissue Ab.

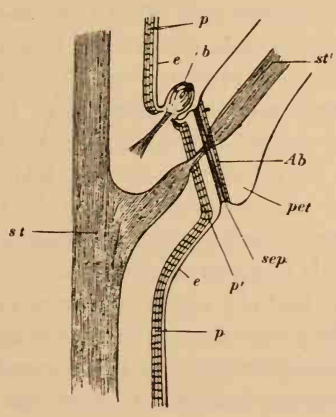


Fig. 58. Diagrammatic vertical section through the insertion of a leaf to show the method of abscission preceding the leaf-fall. *e* epidermis; *pet* base of petiole; *st* vascular bundles and other elements of the central column passing into the petiole *st'*; *b* axillary bud; *p* periderm or cork passing across the petiole at *p'*; *Ab* abscis-layer crossing the narrowed vascular bundles; *sep* line of separation.

Soon after the completion of this plate of cork, changes occur in the median plane of the layer *Ab*, along the line *sep* in the figure, which result in a loosening and separation of the parts along this plane, and the now top-heavy leaf, aided, it may be, by wind or dew, &c., falls away (Fig. 57), leaving a bare patch, or scar, the shape and size of which depend on the sectional area of the leaf-stalk in the region *pet* (Fig. 58). The thin layers of tissue between *sep* and *p'* now dry up, and would of course expose to the exigences of wind and weather the tissues of the shoot-axis on the inside, were it not that the layer of cork (*p'*)

has intervened to protect the surface of the scar. The little strand of vascular tissues of the petiole—termed leaf-traces, and indicated above by *st'*—which join on to the vascular strands of the shoot-axis *st*, are commonly narrowed in the regions just referred to, and the apertures of the projecting vessels cut at *sep* become blocked up. These leaf-trace-scars remain visible, however, long afterwards on the surface of the leaf-scar (see Fig. 59).

The layer of tissue (*Ab*) which brings about this process of cutting off or separation of the leaf is termed the abscis-layer, or we may call it simply the separation-layer. The layer of cork (*p'*) which covers over the surface of the scar—heals it up as it were—is not continued over the base of the bud (*b*), which is moreover connected by vascular bundles, not shown in the diagram, with the strands *st*, because this bud has to be supplied with water and food-materials to enable it to grow out next spring.

We note that this axillary bud, left on the shoot-axis denuded of its leaves in the manner described, stands in definite relation to the leaf-scar, here just above the latter, and although there are variations in the exact position of such buds relative to the leaf-scars, this is the typical condition of affairs.

CHAPTER XIV.

TWIGS.

Definition—Winter twigs—Tegumentary layers—Surface characters —The colours of twigs.

In the narrower sense of the word, as here employed, a twig is the shoot which has passed through its period of growth in length, and on which no new leaves or other structures appear in the ordinary course of events—i.e. apart from anything of an adventitious or abnormal character which may be formed owing to injuries or other stimuli. Confining our attention principally to our deciduous trees, the twig in its winter state usually exhibits the following peculiarities.

Its epidermis, except in a few rare cases where that layer is capable of living for many years as in the Mistletoe, is being replaced or has already been replaced by corky tissues, or periderm, the pressure of which causes the former to split or flake off, and changes the previously green colour of the shoot to some other colour. That green colour was due to the hue of the chlorophyll in the cells of the cortex shining through the thin semi-transparent single layer of the epidermis: the tint—generally greyish to olive or brownish—which predominates as the periderm develops, is due partly to

the colour of the corky layers themselves, and partly to the transmittal of the green hue beneath, in a subdued shade, through the more opaque periderm. Moreover the shade of colour may be modified by the persistence, relative opacity, and colour of the films or flakes of dead epidermis and by hairs, secretions, and other peculiarities. It is chiefly due to the gradual thickening and increasing opacity of the periderm, however, that the colour of the twigs changes as they become older, and pass into the stage we term branches. With respect to the surface characters of twigs, there are several points to be noticed.

As already stated the predominating colours are greys, olives and browns, more or less sharply marked off from the green hue of the shoots; but conspicuous exceptions exist.

Pure whites are not common, but they occur on the branches of the Birch, usually mingled with patches of grey and brown: grey whites are met with in Barberry, Beech and Walnut.

Greys are common. The silvery metallic greys of the twigs of Sea Buckthorn and *Elæagnus* are due to scurfy stellate hairs, which reflect the light; and the glistening and often silvery greys on twigs of Oak, Chestnut, &c., are due to the as yet uncast epidermis, and a grey glint is frequently seen on twigs of *Ribes*, Blackthorn, Cherries, Hawthorn, &c., due to the same cause.

Whitish greys, passing to ash-grey and dirty greys, are common on twigs of Red and Black Currants, Buckthorn, Gooseberry, *Lonicera Xylosteum*, *Salix aurita*, Yew, Oak, Guelder Rose, Hornbeam, Rowan and *Populus alba*.

Pale greys also occur in Robinia, *Pyrus Sorbus*, Birch, *Euonymus* and the Dogwood; and in Elder, Rowan, Cherry, *Prunus Avium*, *Lycium*, *Symphoricarpos* and Currants. Dull greys are also found in the Beech, and

peculiarly patchy or checkered greys of various shades in the Plane and Guelder Rose.

Yellowish greys are met with in Clematis, Guelder Rose, Larch, Bittersweet and Lilac, and

Greenish greys in Hornbeam, Oak, White Poplar, Plane, Ash, and *Salix pentandra*; passing to

Olive-greys in the Aspen, Black Poplar, *Populus canadensis*, Privet, Ash and Walnut.

Brown-greys occur in *Daphne Mezereon*, Hazel, Pear, *Symphoricarpos*, Elder, Beech and *Ribes nigrum*; also in *Pyrus torminalis* and Horse-chestnut.

Dark slaty greys to nearly black-greys are met with in Alder, Aspen, Rowan, Lilac, Hornbeam, Elm, *Morus nigra*, Chestnut, Sycamore, &c.

Reddish greys often characterise the twigs of *Acer platanoides*, Hawthorn, Larch, *Salix alba* and *Pinus sylvestris*; while the greyish twigs of the Spindle Tree often have a violet cast over them.

Pure yellows are not common, but the twigs of the Golden Osier are bright cadmium or chrome yellow, like yolk of egg, and the yellows of *Populus nigra*, *P. canadensis* and *Salix repens* are sometimes striking, though like those of *Salix fragilis* and *Abies pectinata* generally duller.

But tawny or leather yellows, varying much as do the tints of leather straps and travelling bags, are by no means rare, and occur in the twigs of *Acer campestre*, the Sycamore, Larch, Wayfaring Tree, White and Crack Willows, Honeysuckles, Black and Canadian Poplars, Barberry, Elder and *Sambucus racemosa*; while twigs of *Ulmus campestris* and of *Pinus sylvestris* incline to orange or reddish yellows.

Brown-yellows are found in Sycamore, *Salix viminalis*, the Vine, *Ampelopsis* and Barberry.

Reds are rare, except as tinging other colours, but the twigs of *Cornus sanguinea* are often brilliant blood-red as the winter advances, and those of the Lime, though usually inclined to brown-red, may also be bright.

Reddish hues also often prevail in Tamarisk, *Salix purpurea* and *S. fragilis*, the Pear, Almond, Dogwood, Lime and Larch, the latter being occasionally quite pale red or pink; and the twigs of Clematis frequently turn violet-red. Red tints are frequent on the sides of otherwise green or olive shoots where exposed to the sun—e.g. *Salix triandra*, Roses, Blackberry, &c.; and brown-reds, leading to the warm red-browns to be considered below, are exemplified by the Juniper, *Salix repens*, &c.

Brown is one of the commonest colours of twigs and branches, but there is a wide range of shades: perhaps these fall most naturally under the heads of the duller, or grey-browns, the warmer red-browns, the yellow-browns, and olive-browns, but they pass gradually one into the other.

Browns are met with in Robinia, Birch, Pear, Apple, Plum, Cherry, *Prunus Avium*, Rowan, and *Betula nana*; paler brownish hues in Fig, Walnut, Black Mulberry, Guelder Rose, Wayfaring Tree, Azalea, Honeysuckle, *Quercus Cerris* and *Q. coccinea*; dark browns in the Dwarf Birch, Elms, Cherry, *Prunus Avium*, &c. Brownish hues also occur in Spindle Tree, *Symphoricarpos*, Lilac and Privet.

Yellow-browns are found in Wayfaring Tree, Black and Canadian Poplars, *Ailanthus*, Sweet Gale, *Daphne Mezereon*, *Acer campestre*, Aspen, and Honeysuckles; and yellowish browns in Horse-chestnut, Laburnum, and Wayfaring Tree, and with reddish shades in *Acer platanoides* and Pear. *Morus nigra* is often yellowish grey-brown.

Red-browns often prevail in Chestnut, Robinia, Elms,

Pyrus torminalis, Rowan, *Pyrus Sorbus*, Cherry, *Prunus Avium*, Birch, Hawthorn, Dogwood, Scots Pine, Spruce, *Ailanthus*, Sweet Gale, Alder, Oak, *Salix purpurea*; and darker red-browns in Sea Buckthorn, *Elæagnus*, Cotoneaster, *Rhamnus catharticus*; paler, reddish browns in Sweet Gale, Apple, Blackthorn, Birch, Sycamore, *Rhamnus Frangula*, *Salix aurita* and Yew. The Bird Cherry is frequently cherry-red-brown, and *Pyrus Aria* inclines to red-olive-brown; while violet-brown occurs in Sweet Gale and Alder, and purple-brown in *Salix repens*, Tamarisk and Apple.

Grey-browns are common, and are met with in Black and Canadian Poplars, Barberry, *Rhamnus Frangula*, Gooseberry, Lilac, Rowan, Beech, *Sambucus racemosa*, Scots Pine, Horse-chestnut, Beam, Maples, White Mulberry, Larch and Honeysuckles; darker grey-browns, passing towards slate-colour, in Tamarisk, Apple, Blackthorn and Pear, until the shade is nearly black-brown in Sweet Gale.

The remarkable metallic golden-brown or bronze of the Sea Buckthorn depends on the scale-like hairs already referred to.

Olive-browns are also not rare. Beginning with the greenish browns of *Daphne Mezereon*, Laburnum, and *Salix pentandra*, we get more decided olive-browns in Bird Cherry, Pear, Beech, *Quercus rubra*, Hornbeam, Hazel, Alder, Elms, Oak, White Poplar, Dogwood, *Rhus typhina*, *Salix viminalis*, *S. alba* and *S. fragilis*, passing to olive-grey-brown in Black Mulberry and olive-red-brown in *Acer platanoides*.

Returning now to the green tints of *Sarothamnus*, Laburnum, Spindle Tree, Almond, Roses and Blackberry, and characteristic of the shoots and twigs of evergreens generally—e.g. Holly, Furze, Cherry Laurel, *Aucuba*,

Ivy, &c., we find particularly dark shades of green in the Alder and of matt-green in the Spindle Tree.

Grey-greens occur in Sycamore and Laburnum; and yellow-greens in Mistletoe, Elder and Sycamore; while the twigs of *Salix purpurea, S. viminalis* and Aspen, &c., are often greenish, and the brown-green of the Spindle Tree carries us to the olive shades—e.g. the brown-grey-olive of *Salix viminalis.*

Olive-greens are common, e.g. in Dogwood, Lime, Maples, Elms, Lilac, Ash, Fig, *Ailanthus,* White Mulberry, *Quercus Cerris, Q. coccinea,* Walnut, Robinia, Chestnut, *Pyrus Sorbus* and *P. torminalis,* Hawthorn, Clematis, Planes, and some Willows, e.g. *Salix viminalis* and *S. purpurea.*

Browns and greys, &c., are often so dark as to suggest black, as in the deep brown-black of the Blackthorn, and the intensely dark olive of the Alder; and the twigs or branches of Cotoneaster, *Rhamnus catharticus, Quercus Cerris,* Birch and *Betula nana* may be blackish.

Pure blues, violets or purples perhaps never occur; but the twigs of *Salix purpurea* and Alder are frequently purplish, and those of Roses and Blackberries reddish violet on the sunny side, while the Honeysuckles may have bluish or violet hues towards the tips, and those of *Rhamnus Frangula* are often dark violet. But probably the finest approach to true purple is found in the plum-purple branches of *Salix daphnoides,* on which the white waxy bloom sometimes produces glorious shades of blue and violet.

CHAPTER XV.

LEAF-SCARS AND LENTICELS.

Marks on winter twigs—Buds and leaf-scars—Sizes of terminal buds—Aborted buds and pseudo-terminal buds—Sympodia and false dichotomy—Leaf-scars—Their sizes, shapes, &c.—Leaf-trace bundles—Scars of bud-scales—"Spurs" or Dwarf-shoots—Thorns—Buried buds—Lenticels, or "Cork-warts."

THE principal objects or marks to be commonly observed on winter twigs are buds, leaf-scars, and lenticels.

Buds we have already dealt with in detail, and it suffices to remember that in their relations to twigs the chief points are, the arrangement of the buds—a matter in intimate association with that of the leaves in the axil of which they arise, and therefore of the leaf-scars which mark the insertion of the latter; and the presence or absence of a true terminal bud, and its relative size as compared with the lateral buds. It is a common event to find the terminal bud distinctly larger than the lateral buds, and often of a somewhat different and more symmetrical shape, because it has not been subjected to the lateral pressure of the leaf-base, and has been more uniformly exposed to light and other factors of the environment acting on it on all sides.

Trees and shrubs with the terminal or pseudo-terminal

bud more or less conspicuously the larger, except where flower-buds occur, are

Barberry	*Azalea*	Walnut
Ash	Rowan	Mulberry
Fig	Black Poplar	Beam
Wayfaring Tree	Horse-chestnut	Pear
Maples	Sycamore.	

Even in many of the cases where all the buds appear approximately equal in size, careful examination of strong shoots usually shows that the terminal bud is the larger.

But a further point arises in connection with the terminal bud. In very many plants with the twigs ending in a bud, close investigation shows two scars beneath it, the characters of which enable us to say with certainty that they are not both leaf-scars. The Lime affords an excellent example. At the base of the bud, on one side of the apex of the twig, there is a scar which marks where the last leaf of the shoot was attached, and in the autumn we find a leaf still there: immediately opposite is a smaller scar, in place of which we find a bud in the autumn, before the leaves have fallen. The apparent terminal bud of the Lime-twig is therefore really an axillary—and therefore properly a lateral—bud which has usurped the place of the true terminal bud, the latter having died off and left its scar.

Such pseudo-terminal buds are very common. They occur in

Birch	Lime	Aspen
Black Poplar	White Poplar	Hazel
Elms	Willows	Hornbeam
Beech	Oaks.	

When in the following year the pseudo-terminal bud develops into a shoot, the latter continues practically

the line of growth of the twig, but it is evident that, morphologically considered, the new shoot is a lateral shoot to the twig and a sympodial system—i.e. a shoot made up of several successive stretches of lateral growths straightened out—has been originated. It is noteworthy that in some cases the Oak and Beech really do retain the true terminal bud.

In twigs on which the buds are opposite, the death of the terminal bud often takes place at a later date, and there follows a curious result, slightly different in its effects from the above but depending on the same principles.

For instance, the Horse-chestnut, a tree with opposite and decussate leaves and buds, has normally a true terminal bud (Fig. 7); but it is a common occurrence to find the twig ending in a pair of buds, of equal size and with their long axes diverging from that of the twig, and in the angle between them a saddle-shaped scar (Fig. 18). This scar shows the true termination of the twig, and marks the situation of what was a bud in the previous spring, but which developed into an inflorescence, and died off in due course, thus causing the twig to end blindly.

A similar false dichotomy, as this forking of the twig is termed, is very common in trees with opposite buds, of which the true terminal bud is prone to develop into flowers or to die off when young, e.g. in

Horse-chestnut	Lilac	Syringa
Guelder Rose	Wayfaring Tree	Sycamore
Maple	Elder	Privet
Spindle Tree	Dogwood	*Staphylea.*

Obviously these abortions of the true terminal buds bring about differences in the form of branching of the twigs, which, however slight they may appear at this early

stage, profoundly affect the whole branch-system later on; and we shall see that there are numbers of other cases of arrest of onward growth of the twigs to be considered subsequently.

The leaf-scars are the surfaces of insertion whence the leaves have fallen, covered with a thin protective layer of cork, formed beneath the separation-layer (absciss-layer) which brought about the cutting off of the leaf from the stem as described on p. 105, and their position of course marks that of the previous leaves—i.e. they are closely crowded, opposite or alternate, spirally arranged or distichous, accordingly.

Leaf-scars differ much in size, in shape and in prominence; the latter according as the absciss-layer was formed close to, or further up the leaf-stalk from, the plane of insertion of the leaf.

The following have large leaf-scars:—

Horse-chestnut	Walnut	*Ailanthus*
Ash	Elder	Fig.

That is to say in cases where the leaves are large and have a large pulvinus at the base of the petiole.

In the following the leaf-scars are very small:—

Pines	Firs	Larch
Yew	Cedars	Cypress
Tamarisk	Willows	Broom
Whin	Furze	Barberry
Buckthorn	*Daphne*	Cherry
Almond	Plum	Blackthorn
Bird Cherry	Apple	Pear
Sea Buckthorn	Hawthorn	Laburnum
Sweet Gale	Elm	Birch
Beech	Hornbeam	Privet
Honeysuckle	Spindle Tree	*Symphoricarpos.*

In most of the other species to be dealt with the leaf-scars are of medium size.

Their shapes differ exceedingly, and are best understood with reference to Fig. 59.

The leaf-scars are nearly circular in the Fig (Fig. 59 *a*); shield-shaped or heart-shaped in the Horse-chestnut and *Ailanthus glandulosa* (Fig. 59 *b* and *c*); more or less Y-shaped, U-shaped, or V-shaped in the Walnut, the Vine, *Ampelopsis hederacea*, and Maples (Fig. 59 *d, e, f*); crescentic in the Sycamore, Apple, some Oaks, Roses and Blackberry, Red and Black Currants, Rowan, Wayfaring Tree, Guelder Rose, Dogwood, Pear, Beam, and Willows (Fig. 59 *g, h*); almost ring-shaped in *Rhus typhina* and the Plane (Fig. 59 *i, k*); approximately half-moon-shaped in the Aspen, Turkey Oak, Red Oak, Black Poplar, White Poplar, Lime, Barberry, Laburnum, &c. (Fig. 59 *l, m, o*); more or less kidney-shaped in some Oaks, Plum, Sweet Gale, Honeysuckles, Buckthorn, *Genista tinctoria*, Cherries, &c. (Fig. 59 *n, p*); nearly elliptical in Beech, Hornbeam, the Bird Cherry, Privet, *Daphne*, the Sea Buckthorn, Elms, *Symphoricarpos*, Broom, &c. (Fig. 59 *q, r, s*); and nearly a straight linear scar in the Birch (Fig. 59 *v*).

Since the vascular bundles forming the venation of the leaf pass down the petiole or leaf-stalk into the twig, there to join the vascular strands of the stem, it follows that when the leaf falls these bundles are cut across at the plane of the separation-layer, and their transverse sections are left on the leaf-scar. In the case of the larger leaf-scars these cut ends of the leaf-traces—the term applied to the groups of vascular strands passing from leaf to twig—are very evident; for instance they represent the "nails" in the "horse-shoe" of the "hoof" which the leaf-scars of the Horse-chestnut or of *Ailanthus* (Fig. 59 *b* and *c*) may be said to represent.

Now it is noteworthy that the numbers and arrangement of these leaf-traces are very constant in the leaf-scars of the various species of trees and shrubs, as Schwartz and other forest-botanists, and especially Schneider, have shown.

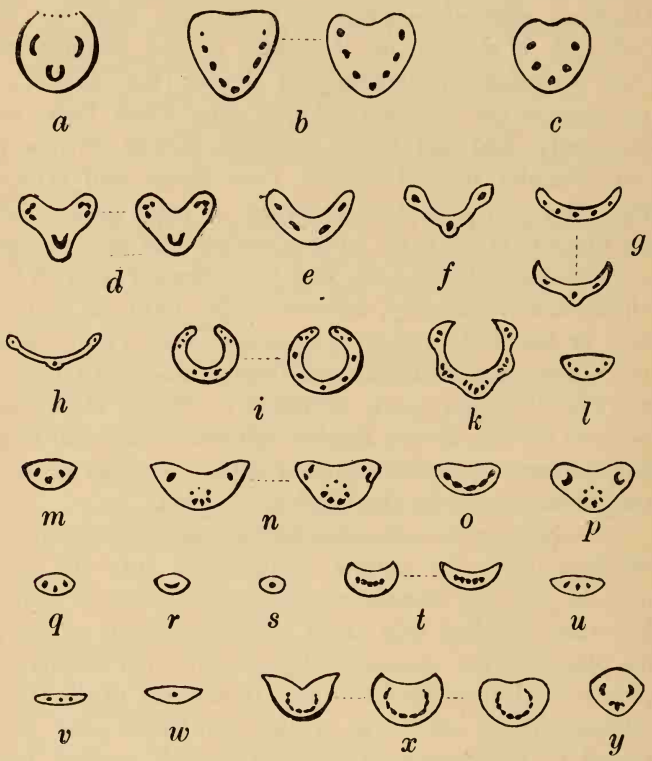


Fig. 59. Types of leaf-scars. *a* Fig; *b* Horse-chestnut; *c* *Ailanthus*; *d* Walnut; *e* Vine; *f* Maple; *g* *Pyrus*, Willow, Sycamore; *h* Rose; *i* *Rhus*; *k* Plane; *l* *Quercus Cerris*; *m* Elm; *n* Oak; *o* Lime; *p* Chestnut; *q* *Prunus*; *r* Privet; *s* *Hippophaë*; *t* Mulberry; *u* Hornbeam; *v* Birch; *w* *Viburnum*; *x* Ash; *y* Alder.

For instance, there is only one small leaf-trace visible in the small leaf-scars of *Daphne*, Sea Buckthorn, *Symphoricarpos*, Larch, &c. (Fig. 59 *s*), and a somewhat larger one of several fused bundles in the Blackthorn, Privet, Almond, and the Spindle Tree (Fig. 59 *r*).

Three separate leaf-trace scars are very common in rather small, and crescentic, elliptic, V-shaped, or similarly shaped scars, e.g. in Willows and Poplars, Buckthorn, *Genista*, Guelder Rose, Wayfaring Tree, Dogwood, Honeysuckles, Elder, Beech, Hornbeam, Pear, Beam, Cherry, Bird Cherry, Laburnum, Apple, Black and Red Currants, Plum, Roses, Blackberry, Elms, and Birch (Fig. 59 *f*, *g*, *h*, *m*, *q*, *u*, and *v*). Even large leaf-scars sometimes have three groups of bundles forming their leaf-traces as in the Fig (Fig. 59 *a*), but the rule is that large scars have a larger number.

Four is an exceptional number of leaf-trace scars, but it occurs in the Vine and Virginian Creeper (Fig. 59 *e*).

Five is a more common number, and occurs in *Ailanthus*, Rowan, the Sorb, &c. (Fig. 59 *c* and *l*), and is occasionally found in other cases with the bundles more or less approximated or fused into one or more groups, e.g. in Hazel, Hawthorn, Bird Cherry, Lime, White Poplar, Alder, and Mulberry (Fig. 59 *o* and *y*).

The number seven and higher numbers are also fairly common in the Horse-chestnut, Walnut, Oaks, Chestnut, Ash, *Rhus typhina*, &c., and here again the bundles or traces may be separate (Fig. 59 *b*) or more or less grouped (Fig. 59 *i*, *k*, *n*) or fused in various ways (Fig. 59 *d*, *p*, *x*). It is not always possible to insist on these numbers exactly, because weaker or smaller leaves on one and the same twig may occasionally have fewer traces than those found in the leaf-scars of normal leaves, but the approximate

numbers of groupings referred to are useful in many cases of diagnosis.

Most twigs exhibit a series of crowded scars at the base, usually thinner and smaller than those along the length, and in many cases provided with fewer and finer leaf-trace scars than the normal. These narrow and crowded scars are those of the bud-scales which enveloped the present twig when it was in the bud state, and before it had elongated to a shoot, and they therefore mark the limit of the previous season's growth (Figs. 46 and 47). Moreover these ring-like groups of crowded bud-scale scars persist for several, or even many years, and if we search back along the older twigs and branches of a normally grown specimen, they may be found clearly delimiting the successive annual growths of the branch. Every stretch of ordinary nodes and internodes, reaching outwards or upwards from one of these groups of scale-scars to the next above, marks the length of extension of the branch for one year; and, of course, the length of clear twig extending beyond the last group of scale-scars to the terminal bud marks the growth of the season just past. When the present terminal bud unfolds next spring, its bud-scales will leave similar scars, closely crowded, because the internodes between bud-scales do not elongate, and will in like manner occupy the base of next year's twig when the seasonal growth has been completed.

It will now be intelligible why the leaf-scars are so crowded on the so-called spurs, or dwarf-shoots of many trees (Fig. 51): it is because the internodes between the leaves on such dwarf-shoots elongate little, if at all, more than do those between the bud-scales which covered them the previous year. In many trees these dwarf-shoots go on giving rise to further dwarf-shoots year after year, each season's growth in length being little, if any, greater than

that of the whole bud; consequently the entire length of a dwarf-shoot may be closely ringed by alternating series of crowded scale-scars and equally crowded leaf-scars, and the leaves on such shoots appear to be tufted.

Considering how different these dwarf-shoots, or short twigs, are from the ordinary long twigs, it will be understood how profoundly they may affect the branching, and this the more in that they frequently bear, or terminate in flowers. They can, however, suddenly change their usual habit; and after growing slowly for many years, a dwarf-shoot, which has only attained a length of an inch to a few inches, may suddenly develop into a long shoot two or three feet long, and then go on growing as a long shoot, or return to its former habit. All these events can be read by the signs afforded by the leaf-scars and scars of the bud-scales.

Dwarf-shoots, or spurs, are prominent on and characteristic of the following trees in winter:—

Apple	Pear	Plum
Cherry	Bird Cherry	Almond
Blackthorn	Larch	Beech
Hornbeam	Barberry	Pines
Cedars	Laburnum	Oaks
Sea Buckthorn	Beam	Rowan
Maples	Buckthorn	Hawthorn.

They are probably never entirely absent from any tree, but in the following their characteristics are less strongly in contrast with those of the long shoots, and have less influence on the appearance of the branching:—

Birch	Lime	Elms
Willows	Plane	Alder
Ash	Walnut	Tamarisk
Vine	*Ampelopsis*	Poplars

Red Currant	Black Currant	Gooseberry
Wayfaring Tree	Guelder Rose	Dogwood
Honeysuckles	Lilac	Privet
Horse-chestnut	Hazel.	

In some cases it is the dwarf-shoots which harden off to a sharp point and form the thorns, e.g. in

Pear	Hawthorn	Buckthorn
Blackthorn	Sea Buckthorn.	

Their true nature is easily detected in such cases by their axillary position or by their bearing buds, &c.

Before dismissing the subject of leaf-scars, it is necessary to remember that in some trees the buds are actually buried in the tissues beneath the scar, and burst forth through the surface of the latter. Conspicuous examples are found in *Robinia* and *Philadelphus*. These cases are to be kept distinct from those where the scar merely surrounds the bud, as in *Rhus typhina* and the Plane (Fig. 19), though they are connected by intermediate conditions.

Most twigs are furnished with small patches of loose-celled tissue, bursting through the epidermis as little heaps, and furnishing passages for the ingress and egress of gases and watery vapour to the tissues of the cortex beneath. These wart-like excrescences are the lenticels, or corky warts, and their formation and structure will be dealt with later on: meanwhile we are concerned rather with their diagnostic value. Lenticels are a prominent feature on the twigs of the following. They are large, or at least conspicuous in

Alder	Walnut	Beam
Poplars	Chestnut	Elder
Horse-chestnut	Maple	Elms
Robinia	Birch	Rowan

Rhus	Bittersweet	Plane
Ailanthus	Buckthorn	Plum
Virginian Creeper	Cherry	Lime
Bird Cherry.		

Definite lenticels appear to be absent from the twigs of the Vine, Syringa, Clematis and Honeysuckle, and they are small and inconspicuous in

Broom	Barberry	*Azalea*
Willows	Fig	Tamarisk
Sea Buckthorn	Laburnum	Pines
Firs	Larch	Cedars
Cypress	Juniper.	

The lenticels are sometimes visible on the shoots, as we have seen, but they are not usually conspicuous until the twig is fully matured, and often not until the second or third years. In some plants, e.g. Cherry, Bird Cherry, Birch and Hazel, they are transversely extended as the branch thickens, and may form long lines extending horizontally round the stem; in others, e.g. Buckthorn, they extend longitudinally but not to any considerable degree. They are often pale in colour, but not always, and the contrast colours with that of the twig are occasionally marked.

CHAPTER XVI.

ACCESSORY CHARACTERS OF TWIGS.

Bloom—Hairs—Pubescence and other forms of hairiness—Bristles and Prickles—Spines and Thorns—Morphology of thorns—Climbing organs — Parasites and Epiphytes — Twiners and tendril-climbers—Morphology of tendrils.

It now remains to specify a series of the accessory characters of twigs, which sometimes profoundly affect their appearance, and which naturally fall into two principal categories.

In the first of these we have a number of epidermal peculiarities, where the structures are superficial and can generally be easily removed by rubbing or by tearing off the outer skin only. The second category comprises structures belonging to, or including in their composition, tissues lying beneath the epidermis, and which can only be removed by cutting or seriously injuring the continuity of the anatomy of the twig.

Among the former, we include the waxy bloom, already referred to in *Salix daphnoides*. This consists of a thin layer of wax, excreted by the cuticle or outermost layer of the epidermis, in the form of minute scales or granules, which cause peculiar reflections of the light and enable water to roll off easily, much as it does off the

similarly greasy feathers of Ducks and other birds, e.g. shoots of Raspberry, Birches, *Myrica*, *Alnus*, &c. Similarly waxy, or sometimes resinous, secretions are poured out by peculiar microscopic glands or epidermal hairs in other cases—e.g. the bud-scales of the Horse-chestnut, Black Poplar, and on the twigs of the Birch, Alder, and Sweet Gale.

This brings us again to the subject of hairiness. The epidermis of the bud-scales and twigs of many species give rise to the minute outgrowths which are termed hairs. When these are sufficiently numerous and long, or when relatively large, they are so obvious to the touch or unaided eyesight as to affect the otherwise smooth surface, and we say generally that the latter is hairy. But as we have seen, hairs differ greatly in character, as any suitable hand-lens will show.

Sometimes they are expanded above into plate-like discs, or scales, and the silvery lustre or coppery metallic sheen of the twigs or buds of *Hippophaë* and *Elæagnus* are due to the reflection of the broken light playing on such scales (Fig. 55).

In other cases the hairs are swollen at their ends into little rounded heads containing semi-fluid, sticky excretions, usually composed of resinous or gummy substances. Such glandular hairs occur on the young shoots of the Hazel and species of *Ribes*, *Rosa*, &c., the flower-buds of *Azalea*, the bud-scales of *Horse-chestnut*, &c. But in most cases the hairs are simple, or occasionally branched filamentous structures containing nothing but air, and in the mass appearing white by reflected light, or, if not sufficiently long and numerous to reflect much light, modifying the smoothness and colour of the twig or bud in other ways; occasionally these hairs are coloured, and the hue of the twig, &c., is altered accordingly, e.g.

the rusty hairs of the shoots of *Pinus Cembra*, twigs of *Cydonia*, and buds of Wych Elm and the dark hairs on the fruit of the Gorse, and the shoots of the Gooseberry.

When the hairs are short, soft and downy, owing to their close crowding, the surface is said to be pubescent —as a general term—or velvety, when the little soft hairs stand up close and dense like the short pile of velvet. Pilose is the term applied when the velvety pile is softer and longer (Fig. 52 *b*); puberulent when it is so slight that the short-piled down is hardly, but just perceptible. Examples are furnished by the puberulous twigs of some Birches, and Chestnut, and the buds of *Prunus Padus* and other species of *Prunus*; the pubescent twigs of *Acer campestre*, Hornbeam, shoots of Blackthorn and *Prunus insititia*, *Quercus Cerris* and *Q. pubescens*, and the buds and shoots of *Rhamnus Frangula*; the velvety pubescent twigs of Apple, Cotoneaster and *Salix viminalis*, and the buds of *Cornus sanguinea*; the velvety pilose shoots of Gorse and *Salix nigricans*; or the pilose shoots of *Rhus typhina*, &c.

When the hairs are looser and longer, and more cottony or woolly to the feel (Fig. 52 *a* and *e*), the peculiar soft hairiness is termed tomentose or cottony, as on the buds and twigs of the White Poplar; but when the pubescence consists of straight hairs, flattened on the surface of the epidermis (Fig. 52 *c*), and glistening white, the appearance is aptly described as silky—e.g. the shoots of Laburnum and the twigs of the White Willow. Similarly silky hairs standing out from the margins of buds and leaves, and fringing them, are termed cilia: the young leaves and bud-scales of the Beech afford a good example (Fig. 26 *d*—*f*), as do also the bud-scales of Elms, Rowan, *Pyrus Aria*, &c.

The peculiar greyish mealy appearance of the shoots

of the Wayfaring Tree, looking as if sprinkled with ashes or flour, is due to branched hairs, and somewhat similar stellate hairs occur on the Plane.

When hairs are quite absent, the surface is said to be glabrous, a term which does not necessarily mean smooth, however, since the hairless surface may be thrown into folds (rugose or wrinkled), or fissured, striate, &c., in various degrees. In many cases the smooth surface is also shining, glistening or polished.

More prominent outgrowths of the epidermis are the bristles and prickles of the Roses, Blackberries and those occasionally found on the internodes of the Gooseberry. These are essentially of the same nature as hairs, but they are much larger and obvious structures. The best simple sign of their superficial character is afforded by the ease with which they can be pushed off the surface by a lateral pressure, when it is seen that they usually come away leaving a scar, and without bringing off any of the underlying tissues.

Other kinds of spinose organs are the pointed outgrowths of the leaves of the Holly, and of *Berberis*, &c., where all the tissues are concerned in their formation, and which cannot be removed without doing injury to the internal structure of the leaf.

Totally different from the above, in origin and in details of structure, are various kinds of spines and thorns, the nature of which is best discovered by the relations of position which they show as regards the buds and leaves, or leaf-scars, on the branches. A true thorn is a sharp-pointed woody structure which either terminates the twig, or is itself a short twig or dwarf-shoot. In the first case its proper character comes out from the fact that it bears buds and leaf-scars lower down on the same axis; in the second case we have the additional evidence that it arises

in the axil of a leaf, or, what is the same thing, from the upper edge of the leaf-scar.

In this way the observer sees at once, from direct observation, that the spines on the Robinia, Gooseberry and Barberry cannot possibly be true thorns, as above defined, because they neither originate from the leaf-axils nor themselves bear buds or leaf-scars, &c. On the other hand the spines of *Rhamnus catharticus, Hippophaë, Mespilus,* Blackthorn and Hawthorn are obviously true thorns, because they either terminate a twig bearing leaves and buds, or they arise in the axils of the leaves and themselves bear such organs. That the latter are merely dwarf-shoots hardened and sharpened at the tip is clearly seen in the Pear, where every gradation between short stumpy blunt dwarf-shoots and sharp thorns is to be found.

In *Genista anglica* and the Gorse the same is true, but somewhat more careful observation is needed to establish the fact when the leaves are absent.

What, then, is the morphological nature of the other spines mentioned above?

In Robinia there is no escaping the fact that the spines originate right and left from the base of the petiole of the leaf: from that part which is left behind on the twig after the leaf has fallen, and in the axil of which we find the buds. And similarly in the Gooseberry, the spines obviously spring from the bases of the leaves, which bear buds in their axils. They are therefore representatives of something belonging to the leaf-base or to the leaf-cushion (pulvinus) found at the base of the petiole. Careful study of their youngest stages, and comparison with other forms, have shown that in Robinia the spines represent the stipules found in other closely allied plants; while in the Gooseberry they arise from the

pulvinus. Consequently they are termed stipular spines and pulvinar spines respectively.

In the common Barberry the case is again somewhat different in detail. As before, we find buds in the axils of the triple or otherwise branched spines, but careful comparison shows that the spines are themselves representative of a whole leaf, and if we pull off the triplet of spines we find that they run down to a common leaf-base, leaving a scar similar to that left by ordinary leaves. Here, then, the spines are leaf-spines.

With regard to other complications of the twigs and branches, they are dealt with in detail in a subsequent section of the book, and it suffices to state here that only very few of the extraordinarily numerous varieties of parasitic plants, e.g. Mistletoe, of twining plants, e.g. Honeysuckles, of tendril-climbers, e.g. Clematis, Vine and Virginian Creeper, and of root-climbers, e.g. Ivy, come within the scope of the present scheme.

The parasite is known at once by its being rooted in the tissues of some totally different plant.

The root-climber is known by the dense masses of pale short roots put out from that part of its stem which is turned away from the light and which adjoins the wall, tree-trunk, or other support, up which it (Ivy) is growing.

The twining Honeysuckles wind their stems round other stems and branches, and occasionally round some of their own.

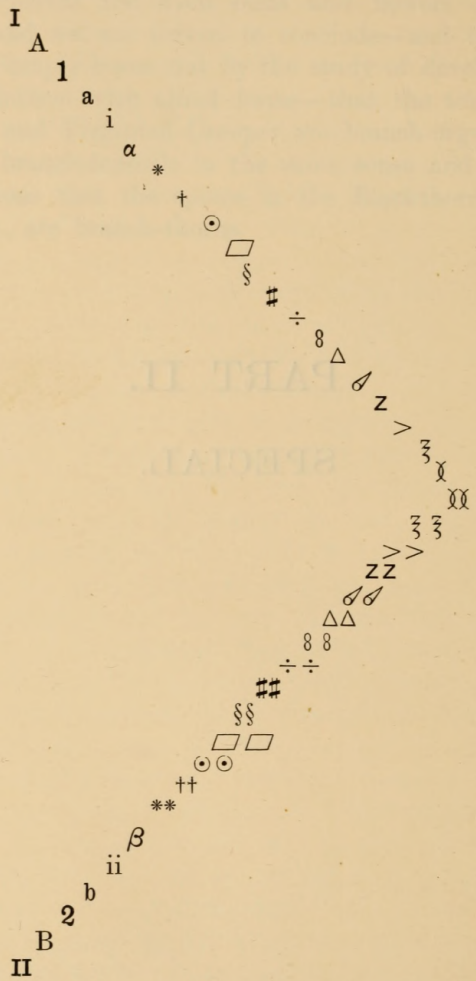
The tendril-climbers here concerned exhibit examples of two chief classes of these remarkable plants. In Clematis the tendrils are seen to be leaf-structures even in winter, because they bear buds in their axils. But the tendrils of the Vine and the Virginian Creeper are obviously not leaves, partly because they do not bear buds in their axils, but also because they arise in the wrong place for a

leaf, seeing that the Vine and *Ampelopsis* have alternate leaves, as we observe from comparison. Still better evidence, however, is afforded by the existence of small scale-like leaves and even buds and flowers on such tendrils, and we are driven to conclude—and the conclusion is amply borne out by the study of development and comparison with allied forms—that the tendrils of the Vine and Virginian Creeper are branch-organs—i.e. they are branch-tendrils in the same sense and for the same reasons that the spines in the Blackthorn, Hawthorn, &c., are branch-thorns.

PART II.

SPECIAL.

In order to facilitate the running down of species in the following classification, the signs in the accompanying list are used in sequence and indented as below :—



CLASSIFICATION OF TREES AND SHRUBS ACCORDING TO CHARACTERS AFFORDED BY THEIR BUDS AND TWIGS.

I. BUDS AT ALL SEASONS ACCOMPANIED BY GREEN FOLIAGE LEAVES ON THE SAME TWIGS: I.E. THE PLANT IS EVERGREEN.

A. BUDS COMPOUND, THE AXIS BEARING BUDS OF DWARF-SHOOTS WITH FOLIAGE LEAVES, IN THE AXILS OF SPIRALLY ARRANGED SCALE-LEAVES; THE TRUE TERMINAL BUD PERSISTENT, LATERAL BUDS FEW AND COLLECTED JUST BELOW THE TIP; ALL TREES WITH BRANCHES IN PSEUDO-WHORLS, AND ACICULAR FOLIAGE LEAVES IN TUFTS OF 2—5 (*Pines*).

[The true nature of the bud, as a bud of buds, is best seen as the young shoot elongates and the tips of the green leaves emerge from between the numerous scales, which may be as many as a hundred to three hundred and fifty.]

(1) **Needles (acicular foliage leaves) in tufts of 5 on the dwarf-shoots, the bases of which are surrounded by scales (perulæ), here deciduous.**

(a) Buds ovoid-pointed and resinous; young shoots glabrous, polished, green; bud-scales lanceolate, acuminate, orange, glabrous; needles long and slender; cones long and pendulous with thin scales.

Pinus Strobus, L. Weymouth Pine. Young branches and twigs with deep olive or slate-coloured smooth surface, passing to wrinkled and fissured bark. Young shoots destitute of leaf-spurs at base. Leaves bright green, with bluish white lines down the sides. Sheath-scales (perulæ) soon falling. Leaf-scar a shallow circular rim.

P. excelsa and *P. monticola* are very similar and hardly to be distinguished by the buds, which are cylindroid, with pale brown deciduous scales; the leaves more drooping and lax in the former.

(b) **Buds not resinous. Young shoots with rusty hairs, and the sheathing scales (perulæ) brown and deciduous, ciliate with whitish hairs; needles short and erect, stiff; cones short, ovoid, erect.**

P. Cembra, L. Arolla or Swiss Pine. The rusty hairy shoots very characteristic and clothed throughout with leaf-spurs. Buds rounded-acuminate, with long brownish red scales. Leaves stiffly tufted, with bluish white lines down the sides. Leaf-scar a shallow circular rim.

(2) **Needles not more than 3 in a tuft; basal sheaths persistent. Buds long-pointed and covered with resin.**

(a) **Needles 3 in each tuft.**

P. Taeda, L. Loblolly Pine. Young branches and stems grey or yellowish grey, smooth, becoming deeply furrowed and resinous as they age. Leaves stiff and vivid green. The brown sheaths of perulæ often slit.

(b) **Needles 2 in each tuft.**

(i) Needles short and bluish green. Buds pale chestnut-brown, covered with whitish resin, rather blunt and aggregated in threes or fours beneath the terminal one.

P. sylvestris, L. Scots Pine, Scotch Fir (Fig. 60). Young branches and stems foxy red or orange-brown,

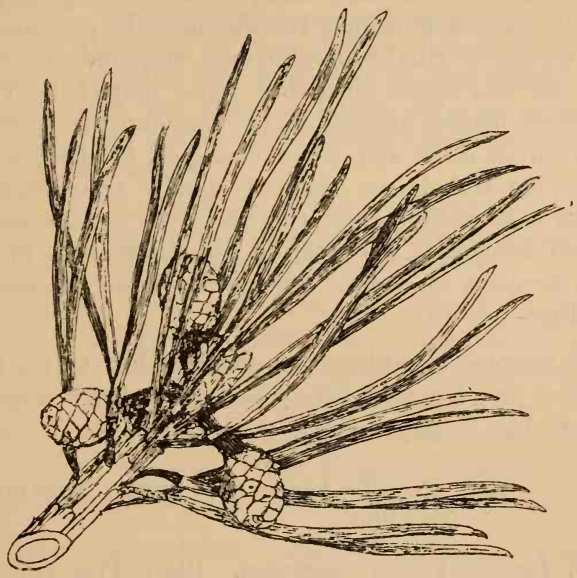


Fig. 60. Scots Pine, *Pinus sylvestris* (D).

shedding scales or flakes, becoming greyer and deeply fissured as the bark forms. Leaves stiff, short and often twisted; frequently bluish or even with a silvery bloom. Sheaths whitish. Young shoots covered with the bifoliate short branches (dwarf-shoots) throughout the length. The terminal and lateral buds are similar in construction, but the latter are confined to a few of the uppermost leaf-axils.

The bud begins with two lateral scales, followed by others in a close spiral. The outer scales are lanceolate and hard, almost woody, and remain at the base of the

shoot with recurved tips. The leaf-scales which follow are ovate-lanceolate, acuminate, green and herbaceous at the base, but eventually harden off, their upper parts delicate and membranous, translucent, with scarious tips and delicately ciliate margins, and surround the shoot until the bud opens, when their upper parts fall. These leaves are densely crowded in the bud and easily rub off. Each carries in its axil a bud, composed of about 8—12 enveloping scale-leaves (perulæ), spirally arranged as in a tube from within which the two green needles emerge as they elongate. The apex of this dwarf-shoot in rare cases develops as a shoot from between the two needles (see Figs. 10—12).

P. montana is hardly to be distinguished by the buds —which are, however, long-ovoid and densely resinous-coated—but is very different in habit.

(ii) Needles longer, dark green: twigs greenish yellow.

P. Laricio, Poir, v. *austriaca*. Black Pine (Fig. 9). The young branches are greenish brown or deep olive-brown and smooth, passing to nearly black, greyish, deeply fissured bark. Buds brown-red, resinous, long-ovoid, with dense silvery scales. Young shoots clothed throughout with the bifoliate spurs.

P. Pinaster, Cluster Pine, and *P. Pinea*, Stone Pine, may be compared with this. The bark of *P. Pinea* is grey-brown, fissured and scaly. The buds of *P. Pinaster* are large and long, not resinous, and have whitish cilia to the scales.

The best distinctions from *P. austriaca* and *P. sylvestris* are the much longer leaves and cones, and the habit.

B. Buds simple—i.e. the bud-axis bears isolated leaves.

(1) Terminal bud persistent; lateral buds from the axils of green foliage leaves which are crowded and numerous on the shoots, and stiff and narrow, linear, acicular or scale-like; seeds naked between the scales of cones, or exposed.

(a) Leaves linear or acicular, dark glossy green, at any rate on the upper surfaces, spirally inserted though often apparently displaced.

(i) Leaves acicular, in tufts of 30—50 or more on short dwarf-shoots, scattered on the long shoots. Buds cylindroid, with few (10—12 or more) pale brown scales; twigs numerous and short; cones large, 10—15 cm. long, erect, ellipsoid-cylindroid, scales thin, numerous, and closely imbricate.

Cedrus Libani, Loud. Cedar of Lebanon. Foliage sprays terraced. Branches with light brown smooth periderm, passing to black-grey fissured bark.

C. Deodara and *C. Atlantica* have very similar buds, somewhat more globoid in the latter.

The Larch is the only other tree likely to cause hesitation here; its habit, cones, deciduous leaves, &c. easily distinguish it (see p. 204).

(ii) Leaves not tufted, but isolated and numerous, spirally inserted but often apparently distichous from being as it were combed to right and left of the twig (pseudo-distichous). Buds scaly, relatively few, those on the lateral shoots sub-opposite.

(*a*) *Buds very small, with few scales, globoid, dark chestnut-brown, the terminal one closely invested by young leaves; leaves linear, flat and pointed (pseudo-distichous); seed single, ovoid, in a scarlet-crimson fleshy arillus.*

Taxus baccata, L. Yew (Fig. 61). Unmistakeable in seed, but the apparently distichous foliage will raise difficulties to beginners with regard to the Silver Fir

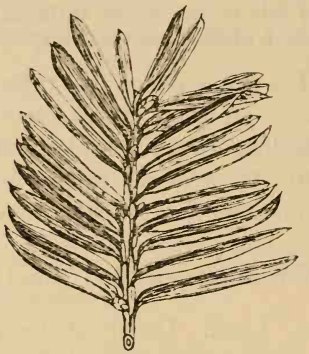


Fig. 61. Yew, *Taxus baccata* (D).

and some other Firs. The reddish scaly bark, pointed leaves, small chestnut-brown globoid buds, irregular branching and tufted habit are useful characters.

(*β*) *Buds larger, 1—2 cm. long, with numerous brown scales, more or less conical-pointed. Trees with true woody cones.*

* Buds dry, not resinous, cylindroid or subconic, pointed, pale brown. Shoots not hairy. Two or three buds terminate each shoot, and one or two sub-opposite occur lower down; pulvini prominent, and leaves 4-angled and hardly pungent, slightly pseudo-distichous. Cones pendent.

Picea excelsa, L. Spruce (Figs. 62 and 13, 14). The buds are about 1 cm. long, dry and with oval-oblong reddish brown scales. Branches sub-opposite on the laterals, with a thin, smooth or corrugated reddish brown or orange-brown periderm, passing to a thin greyer scaly and fissured bark. The bud-scales are usually cast off like a hood, separating below and adhering together at the apex (see Fig. 14). Leaf-scars angular, on projecting peg-like cushions (pulvini).

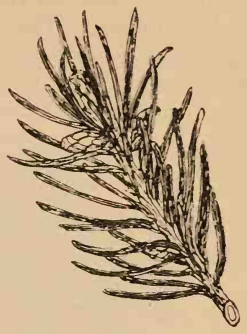


Fig. 62.
Spruce, *Picea excelsa* (D).

** Buds resinous, aggregated 2—3 together towards the tips only; pulvini not prominent; young shoots pubescent; leaves linear, flat, blunt and markedly pseudo-distichous. Cones erect.

Abies pectinata, L. Silver Fir. The mature foliage is not so dark and gloomy as in the Spruce, and is often silvery in youth. Buds cylindroid-conic chestnut-brown. Twigs pale brown, striate and hairy. Branches distichous and sub-opposite on the lateral shoots; greyish brown, smooth, passing to a rugged fissured greyish bark. Leaf-scar a shallow circular rim.

Pseudotsuga Douglasii. Douglas Fir (Fig. 63), with pendent cones, but other characters intermediate between the Spruces and Silver Firs may come here. It has thin, long and pointed buds, with oval-oblong, lustrous sienna-brown bud-scales, fringed with whitish hairs, pointed but not pungent needles, and no prominent pulvini. The buds are ovoid-pointed or conical, 1—2 cm. long and glistening

brown. Old bark very thick, rugged and long-fissured, tending to scale on the ridges, reddish brown, or the ridges darker brown. The best distinction lies in the cones,

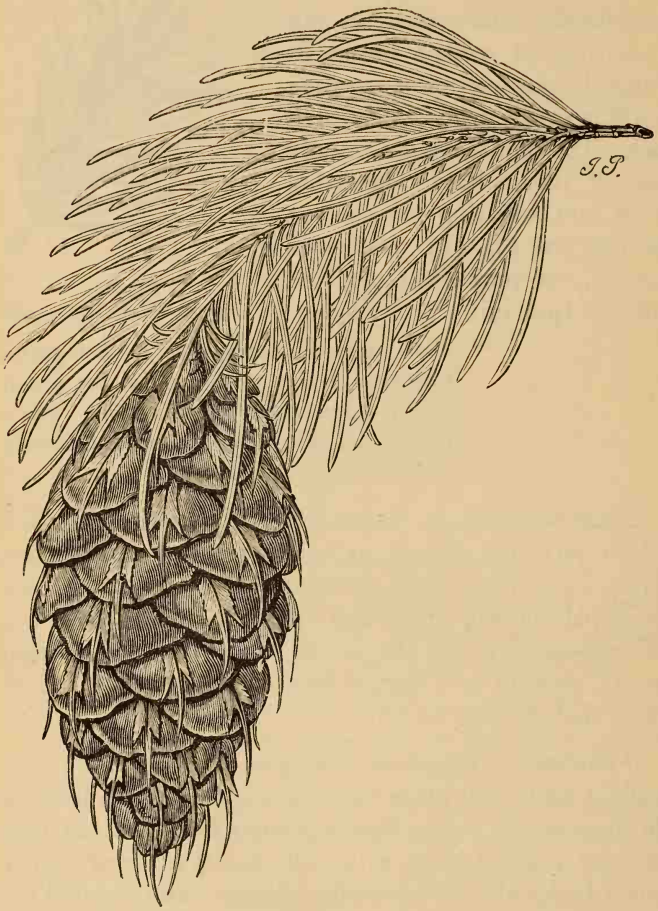


Fig. 63. *Pseudotsuga Douglasii*, showing the pendent cone, and exserted three-pronged barren scales (V).

which have three-pronged scales projecting from between the ordinary scales.

(b) **Leaves crowded and scale-like or subulate, opposite or in whorls of three. Buds very small, green. Cones of very few scales.**

(i) Most or all of the leaves subulate, pungent, spreading in whorls of three. Buds with sharp-pointed leaf-scales in whorls of three. Cones of few fleshy scales fused into a blue-black "berry."

Juniperus communis, L. Juniper (Figs. 64 and 38). Twigs green. Branches with smooth reddish brown surface, passing to grey-brown, scaly bark.

The bud is practically a tuft of young lanceolate-acuminate or almost subulate leaves, of which the two outermost stand right and left of the subtending leaf. These are followed by about three whorls of three leaves each, each whorl alternating, the first therefore with its odd leaf next the axis. Thus the bud is naked, its scales being true leaves.

Fig. 64. Bud of Juniper subtended by the scar of the leaf in whose axil it stands. It consists of alternating whorls of three leaves each.

(ii) Leaves all small, short and scale-like, closely crowded and appressed, in imbricating opposite and decussate pairs. Cones woody.

(*a*) *Twigs short, much branched, compressed; leaves with dorsal resin-glands. Cones of a few erect, opposite, imbricated scales.*

Thuja gigantea, Nutt. Arbor Vitæ. Bark cinnamon-red, irregularly fissured and scaly.

(*β*) *Twigs not flattened; cones with peltate scales.*

Cupressus sempervirens, L. Cypress. The Tamarisk is the only other tree with closely crowded and imbricated, grey-green scale-like leaves, and it differs in all but this superficial resemblance from Cypresses and Arbora Vitæ —e.g. the leaves are alternate, deciduous, and it is a Dicotyledon, &c.

[This type of closely appressed and crowded small leaves on slender shoots is found again in the Heaths (*Erica, Calluna,* &c.) and is sometimes termed *Ericoid.*]

(2) Terminal bud often arrested; branching irregular, not whorled; lateral buds normally one in each leaf-axil; foliage leaves neither linear nor very small or narrow. Trees and shrubs with flowers, and true fruits containing seeds.

(a) Buds, leaves and twigs opposite.

(i) Plant parasitic on various trees; buds small, green, each in the angle between two yellowish green opposite oblong leaves and a terminal inflorescence.

Viscum album, L. Mistletoe. The branches are remarkable for their persistent smooth epidermis, and perennial green colour. The roots extend in the cortex, and are even invested by the wood, of the numerous trees on which it occurs, among which Poplars, Hawthorn,

Apple, &c. are commonest, Oak rarest. The plant is unmistakeable, especially when bearing the greenish white berries. The shoot usually ends in a flower-bud, flanked on either side by a leaf-bud composed of two outer leaves flattened face to face and enclosing about two pairs of decussate leaf-incepts, and with a minute scale at the marginal base on each flank. In the axil of each of these latter scales may be another similar bud.

(ii) Non-parasitic shrubs with shining-green coriaceous leaves.

(*a*) *Buds very small; leaves rather small, oval, dark green and hard.*

Buxus sempervirens, L. Box (Fig. 65). Twigs more or less 4-angled. Old stems, often twisted, with thin flaking dirty yellow bark.

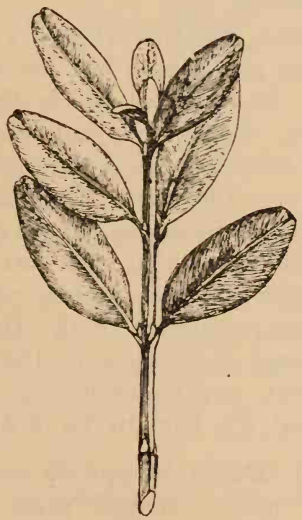


Fig. 65. Box, *Buxus sempervirens* (D).

The Privet, *Ligustrum vulgare*, is frequently sub-evergreen, its opposite lanceolate leaves persisting more or less until the new ones appear (see p. 173).

(β) *Buds large and conspicuous; leaves broad-lanceolate and large, bright green, glossy and supple.*

Aucuba japonica, Thunb. Aucuba. Often termed Laurel, but has nothing botanically in common with *Laurus*. The leaves are often variegated.

(b) **Buds, leaves and twigs alternate.**

(i) Plant armed with spines or thorns. Buds minute.

(*a*) *Leaves large, simple and spinescent, toothed, glossy green.*

Ilex Aquifolium, L. Holly (Fig. 66). Unmistakeable when bearing its red berries, but the spines are sometimes obsolete. The terminal bud is slightly larger than the axillary ones. Each begins with two scales, to right and left of the axis, enclosing a third one next the axis, all folded one over the other. Only about four scales show outside. They are leaves, and are spirally arranged. Close examination shows that each leaf in the bud has two minute stipular points at the base, which abort as the bud opens. This recognition of the Holly as stipulate dates from Henry's observation in 1846: Reissek confirmed it in 1861, and Kronfield also figures them in Engler and Prantl, *Pfl. Fam.* III. Th., 5 Abt., p. 183, 1896.

(β) *Buds obscured by the numerous and much branched green branch-thorns; leaves and scars none or rare.*

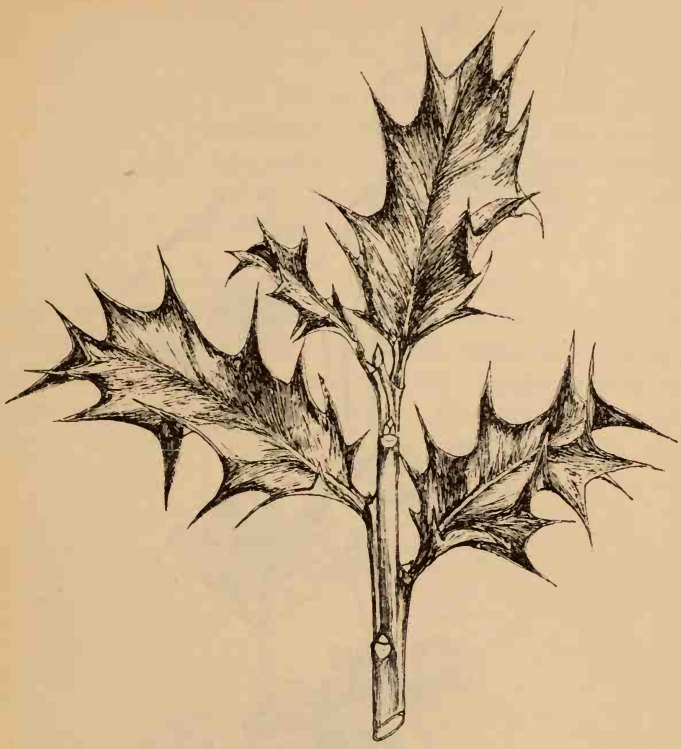


Fig. 66. Holly, *Ilex Aquifolium*, p. 144 (D).

Ulex europœus, L. Furze, Gorse. This is not strictly an evergreen in the sense of having persistent leaves, the latter being small and trifoliate, and cast early. *U. nanus*, Forst., is a smaller bush of similar habit. See p. 190.

The only other armed plants which call for mention here are *Mahonia*, with glossy pinnate leaves, spinescent on the margins, and *Rubus fruticosus*, which is occasionally sub-evergreen (see p. 202).

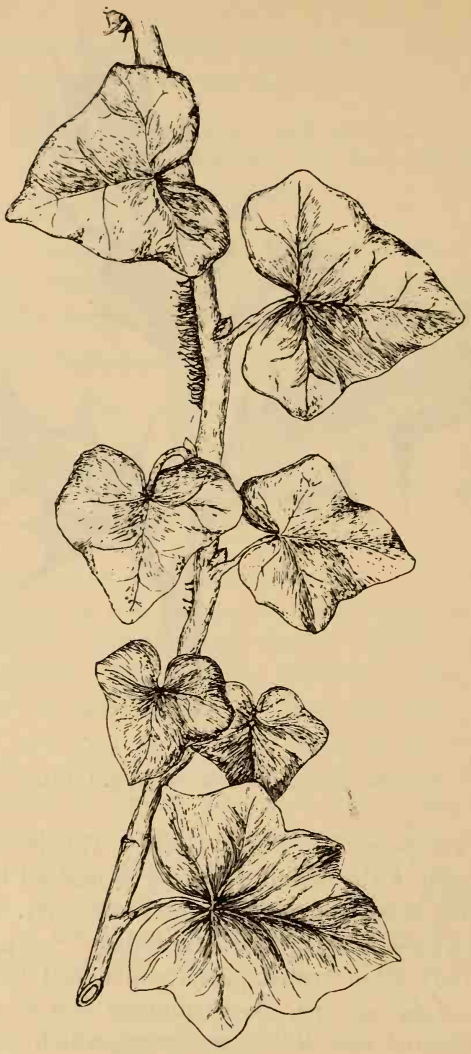


Fig. 67. Ivy, *Hedera Helix*, a climbing shoot, p. 147 (D).

(ii) Plant unarmed. Buds large or at least conspicuous.

(*a*) *Bud naked, conical, pointed, and green, exhibiting one or two folded leaves only, internodes long and naked: leaves broad, angular or lobed, glossy, more or less distichous.*

Hedera Helix, L. Ivy (Figs. 67 and 68). Usually climbing by means of numerous rootlets, but even when creeping or bushy it is unmistakeable, owing to its glossy, palmately veined and often variegated, angular or broadly expanded leaves. The bud-scales are merely reduced leaves, and are distichous on the main shoots; in the

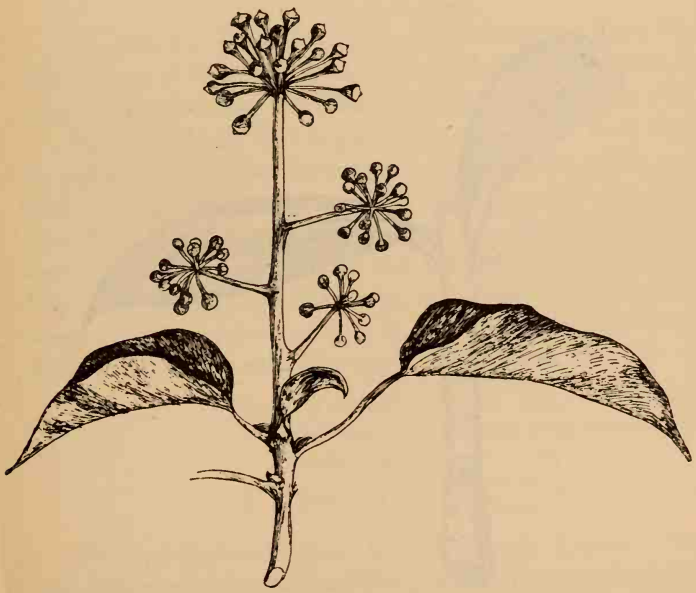


Fig. 68. Ivy, *Hedera Helix*, a free flowering shoot (D).

lateral buds the distichous arrangement passes to a spiral one. The lateral buds are green, and so closely sessile in the axil as to appear sunk in the petiole.

The bud starts with one scale next the axis, followed by about four or five others arranged in a distichous manner, the further leaves gradually passing to a spiral. Leaf-scars narrow, crescentic. Buds obscurely pubescent.

(β) *Buds with numerous obvious scales.*

* Buds aggregated at the tips of the grey or whitish tomentose twigs; scales dry, in 5 ranks.

Quercus Ilex, L. Holme Oak, Evergreen Oak. The leaves are often entire, though typically spinose-toothed

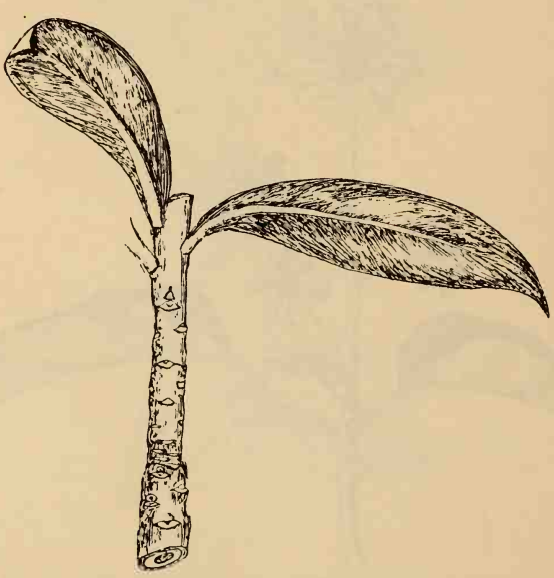


Fig. 69. Spurge Laurel, *Daphne Laureola*, p. 149 (D).

as in Holly, and have a grey-green appearance matching the ash-grey bark and twigs.

Q. Suber, the Cork Oak, with similarly grey-green hard foliage, differs in its corky bark, and its acorns.

Daphne Laureola, L. Spurge Laurel (Fig. 69), a small bush with very supple, tough branches, and shining, coriaceous, lanceolate leaves, also has its buds chiefly at the tips of the twigs. The bud-scales are, however, not in 5 ranks, and are otherwise different.

** Buds not aggregated at the tips of the twigs, and scales not in 5 ranks and dry.

† Buds ferruginous, viscid, ovoid-conic, pointed, and exhibiting about 10—12 long, triangular-ovate, acuminate scales, spirally imbricate; the flower-buds larger.

Rhododendron ponticum, L. Rhododendron, Rose Bay. The terminal buds are usually flower-buds, and relatively very large, each bud-scale having a flower-bud in its axil.

The lateral leaf-bud begins with a scale on each flank to right and left, the third scale next the subtending leaf. The young leaves are revolute and spirally arranged. The dark laurel-like leaves remind one of *Prunus Lusitanica* and *P. Lauro-cerasus*, but the larger viscid buds at once distinguish them; *Aucuba*, with somewhat similarly shaped but opposite leaves, is quite different, and all differ from the true Laurel (*Laurus*). See pp. 144 and 150.

†† Buds small, 3—6 mm. long, not viscid or ferruginous; shrubs with large glossy ovate-lanceolate leaves.

⊙ *Twigs and buds green.*

Prunus Lauro-cerasus, Lois. Cherry Laurel. The bud-scales are stipular, and the young leaves conduplicate

and arranged much as in *Corylus*. There are also resemblances in the internal structure of the buds to those of the Elms, but the stipules are quite different, and overlap as in Chestnut, and the evergreen habit and other characters are markedly different from all these.

⊙⊙ *Buds and twigs purple-red.*

Prunus Lusitanica, Lois. Portugal Laurel. Very like the Cherry Laurel in most respects except the colouring of the shoots.

The only other evergreen that need be mentioned here is the curious little hedge-shrub *Ruscus aculeatus*, the Butcher's Broom, the pointed, hard, leaf-like organs of which are really flattened branches, as proved by their origin in the axils of scale-leaves and their bearing scales, flowers and fruits on their surfaces.

II. BUDS IN THE WINTER UNACCOMPANIED BY GREEN LEAVES, BUT SUBTENDED BY LEAF-SCARS: I.E. THE PLANT IS DECIDUOUS.

A. Buds and leaf-scars opposite and decussate on the long shoots.

(1) Buds, at any rate the terminal one, large and conspicuous, on stout or relatively stout and rigid twigs, with well-marked internodes, and conspicuous leaf-scars and leaf-traces. Plants never armed with thorns, or climbing.

(a) Buds ovoid-acute, viscid or glazed with resin, deep red-brown; twigs very stout, pale grey or grey-brown, smooth; leaf-scars large, mostly shield-shaped, not projecting, with 5—9 isolated leaf-traces.

Æsculus Hippocastanum. Horse-chestnut (Figs. 70 and 7, 8, 18, 57). The terminal bud often wanting and

replaced by the saddle-shaped scar of the fallen inflor-

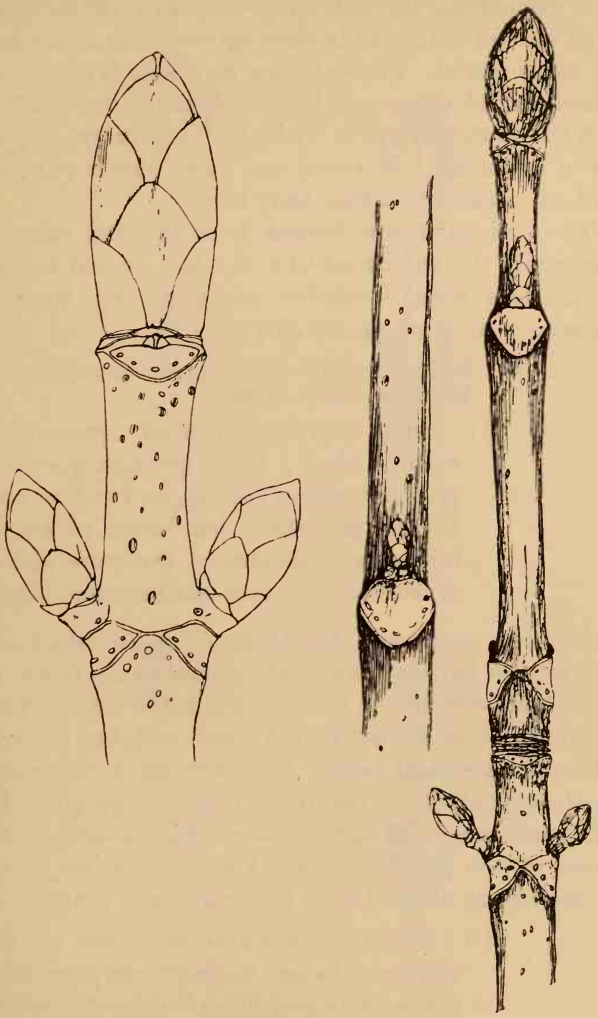


Fig. 70. Horse-chestnut, *Æsculus Hippocastanum*, p. 150 (D).

escence, whence a branch may appear dichotomous. Lenticels evident on the pale grey or brown twigs, against which the red-umber buds show up strongly: scales broad and not bordered. The leaf-scars vary from typical shield- or hoof-shaped to more or less semi-lunate, and may have 5—9 leaf-trace scars (Fig. 59 *b*), not on a protruding leaf-base or cushion. Pith round and white, shoots pubescent, periderm passing to a thin scaly bark.

The bud-scales are formed from the leaf-bases, and occasionally the outermost—i.e. the last formed leaves of the previous season—exhibit traces of the lamina as appendages at their apices (Fig. 8).

(b) **Buds not viscid or glazed; leaf-scars, or most of them, not shield-shaped.**

(i) Buds depressed, conical, quadrangular, velvety black; twigs greenish grey, compressed towards the tip, and nodose, owing to the projecting leaf-bases, which bear lunate or shield-shaped leaf-scars with one curved series of fused leaf-trace bundles only.

Fraxinus excelsior. Ash (Figs. 71 and 6, 59 *x*). The stout smooth twigs are unevenly nodose owing to the projecting leaf-bases in the axils of which the stumpy black-olive buds are somewhat buried; buds with but few scales visible, the terminal larger bud showing 4, the smaller lateral ones only 2—3, and frequently sub-opposite. Lenticels small, scattered and longitudinally extended. Fine fissures on the grey branches. Dwarf-shoots very nodose and curving up at the tips. Pith white and round.

(ii) Buds neither conical depressed nor black velvety; twigs neither compressed nor nodose with projecting leaf-bases; leaf-scars narrow, and transversely extended.

(*a*) *Buds scaly, closed, more or less ovoid-quadrangular owing to the keels of the*

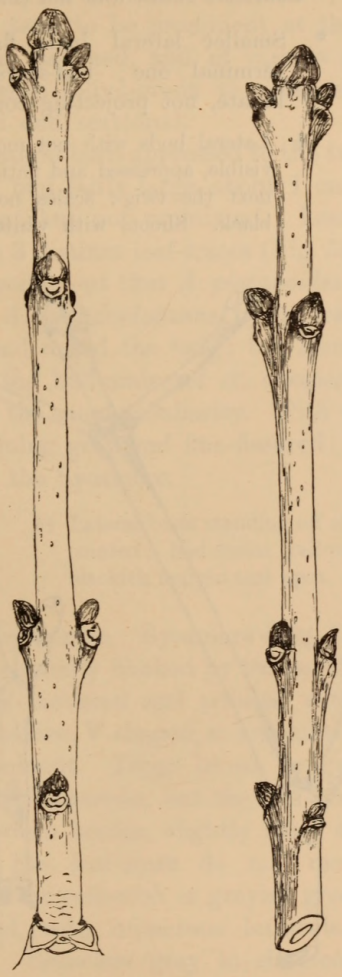


Fig. 71. Ash, *Fraxinus excelsior*, p. 152 (D).

bud-scales; the latter regularly imbricate, decussate, and greenish at least at the base. Lenticels small and not conspicuous.

* Smaller lateral buds flank the large terminal one; leaf-scars V-shaped or lunate, not projecting conspicuously.

† Lateral buds with not more than 3 scales visible, appressed and flattened on the side next the twig; scales not bordered with black. Shoots with white latex.

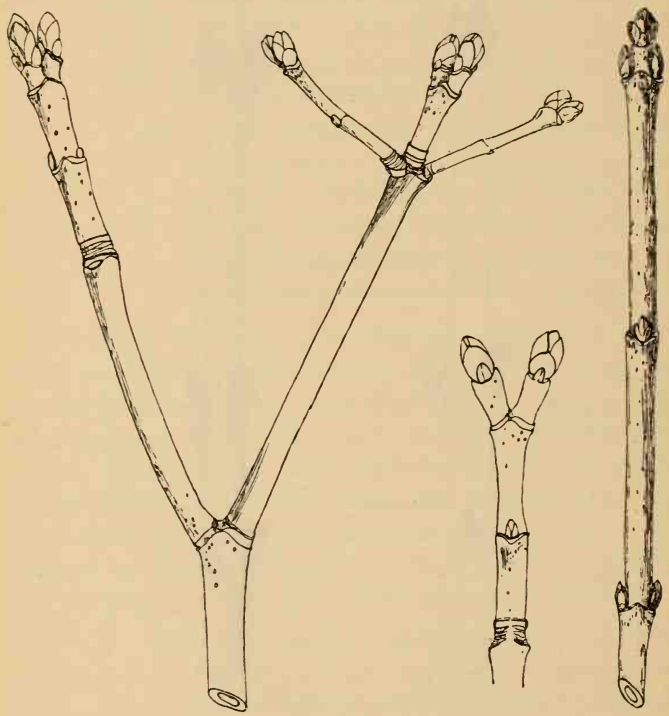


Fig. 72. Norway Maple, *Acer platanoides*, p. 155 (D).

Acer platanoides. Norway Maple (Fig. 72). Bud-scales several, shining, tough and keeled, green or olive at the base and red or red-brown above; finely ciliate. The leaf-bases tend to be prominent at the apex of the twigs, which are polished, and of various shades of red, brown or greenish (olive-green to yellowish red-brown). Lenticels small and scattered.

The small lateral buds appressed to the twig and flat on that side; end bud fairly large, about 1 cm. long. Leaf-cushions evident, but not prominent. Leaf-scar shallow, V-shaped, with 3 distinct leaf-traces (Fig. 59 *f* and *g*).

Schneider points out that *A. platanoides* can be distinguished from *A. pseudoplatanus* by its leaf-scars, which unite end to end round the twig; but Henry had shown, in 1846, that the bud-scales of *A. campestre*, which are leaves, present the same peculiarity. Pith whitish, round. Branches becoming grey and fine-fissured; bark fissured, not scaly as in the Sycamore.

†† Lateral buds standing off at an angle, ovoid-pointed; bud-scales yellowish green, with blackish margin and apex. No white latex.

Acer pseudoplatanus. Sycamore (Fig. 73). The large terminal bud is usually flanked by two small ones. Scales yellowish green bordered and pointed with black. The leaf-scars are shallow, V-shaped, or crescentic, and the leaf-bases not prominent. Twigs brown or grey. In many respects like *A. platanoides*, but the bud-scales olive-green with a deep brown border, slightly hairy at the margins and tip, and the leaf-scars do not meet round the twigs. The latter yellowish or greyish green to brownish yellow, polished, with numerous lenticels. Pith large, round, white. Branches grey to slate-coloured. Bark scaly.

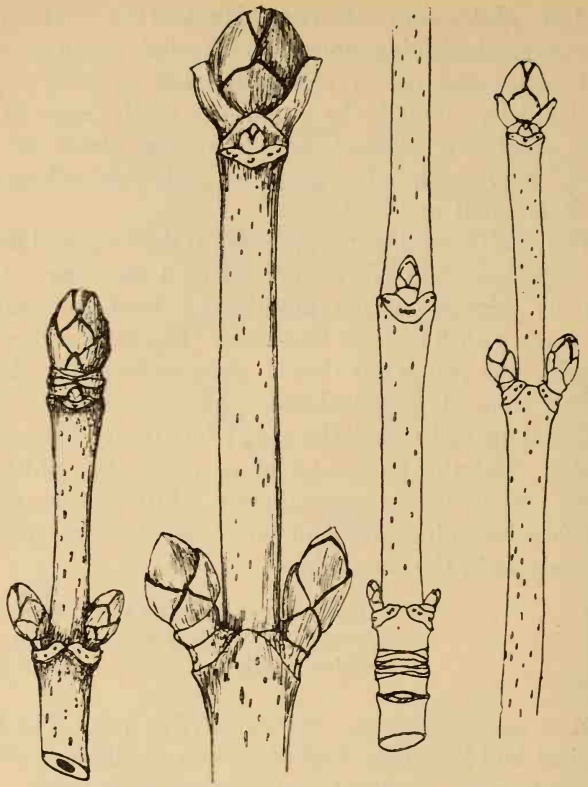


Fig. 73. Sycamore, *Acer pseudoplatanus*, p. 155 (D).

** Two buds in a pair at the tip of the twig, the central termination of the shoot usually absent; buds on the lower parts small; bud-scales green with red or brown margin, and rather loosely imbricated. Leaf-scar lunate-crescentic with one transversely extended linear group of fused leaf-trace bundles. Lenticels distinct but not large.

Syringa vulgaris. Lilac (Fig. 74). The buds are large but variable in size, broadly ovoid, blunt and quadrangular, owing to the keeled scales, which are glabrous and may have a narrow yellowish or reddish to brown margin, or brown splashes all over: the lower buds on the shoot are small, and the terminal one is generally replaced by the scar of the fallen inflorescence, two large buds occupying the flanks. Twigs pale yellowish grey to olive or brownish, not very thick, smooth, and rounded. Leaf-bases not prominent, and scars often not sharply marked. Branches grey to brownish, fissured; bark more or less scaly.

Fig. 74.
Lilac, *Syringa vulgaris* (D).

The bud is slightly sunk in the base of the petiole, and shows about 4—5 pairs of outer, rather hard and leathery valvate scale-leaves, followed by about 10 pairs of young leaves inside, all decussate and just overlapping at the edges (Figs. 5 and 23). The first two scales are right and left, and each may have a minute bud in its axil.

(β) *Buds open and irregularly elongated, exposing the tips of the young green leaves projecting beyond the bud-scales, which are few, short, reddish brown and membranous. Lenticels conspicuous.*

Sambucus nigra, L. Elder (Fig. 75). Twigs pale grey, somewhat angular at the apex, and some of them

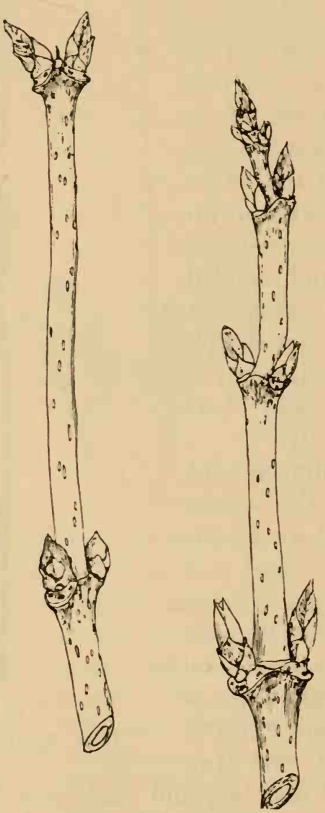


Fig. 75. Elder, *Sambucus nigra* (D).

very long, straight, and thick, but weak and with copious round whitish pith. They are smooth, and occasionally slightly angular; grey or yellowish green, and have particularly large corky dark-coloured wart-like lenticels. The large buds have several olive or greenish brown dry membranous scales below, but the green leaf-tips project above. The buds start opening very early, and the loose scales give them a want of compactness: the irregularly projecting leaf-tips also give the bud a frayed-out look. There are often smaller buds superposed, or even at the sides of the others. Leaf-scars more or less V-shaped or crescentic, with 5 prominent leaf-trace bundles, and often meeting round the twig. The suckers are often very thick, long, and weak.

S. racemosa, the Red Berried Elder, has large, reddish or violet, globoid angular buds loosely enveloped in broad scales, and on short broad stalks.

(2) Terminal bud, when present, not large, and all usually very small before expansion; twigs slender; leaf-scars always narrow or small, never shield-shaped, and leaf-traces minute and few, 1—3 in number.

[The buds of the Honeysuckles open so rapidly and early in spring, that they may be regarded as large: it is therefore necessary to remark that they have loose open scales, and are on slender twigs, climbing or not, with inconspicuous leaf-scars and leaf-traces; see pp. 163 and 164.]

(a) Twigs mostly ending in thorns; buds erect, appressed, sub-opposite, ovate-acute, and showing about 4—5 pairs of scales; dwarf-shoots strongly ringed and usually ending in a bud.

Rhamnus catharticus, L. Buckthorn (Figs. 76, 77, and 28). The buds are ovate-pointed, dark brown to blackish,

with smooth slightly ciliate scales, which show traces of spiral arrangement.

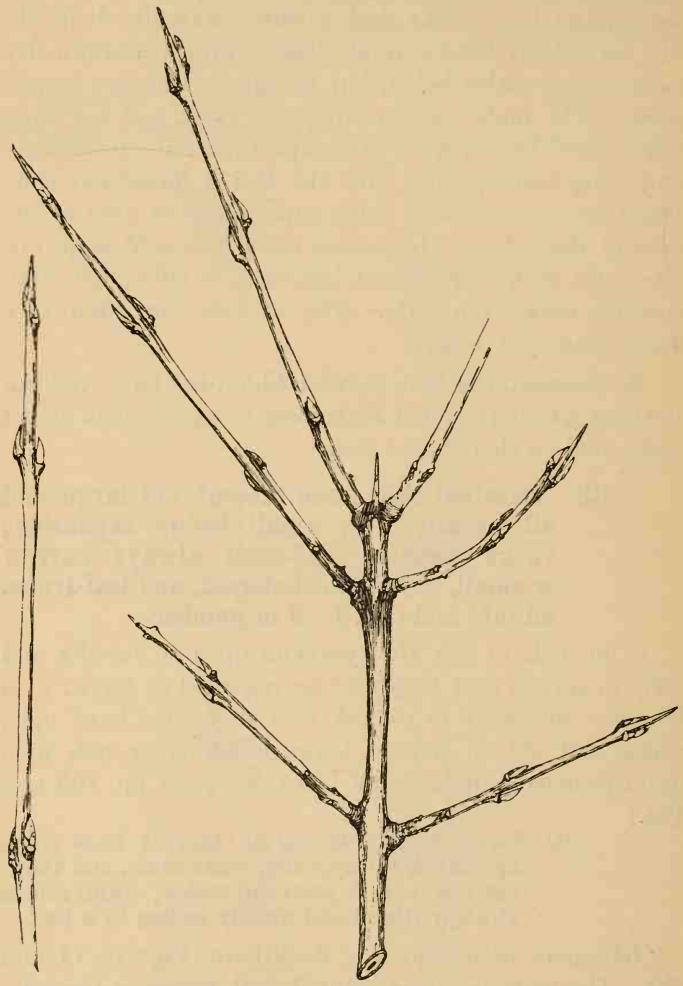


Fig. 76. Buckthorn, *Rhamnus catharticus*, long shoots, p. 159 (D).

Bud-scales brown-black, blunt, slightly keeled and ciliate; leaf-scar small, semi-lunate, with 3 minute and

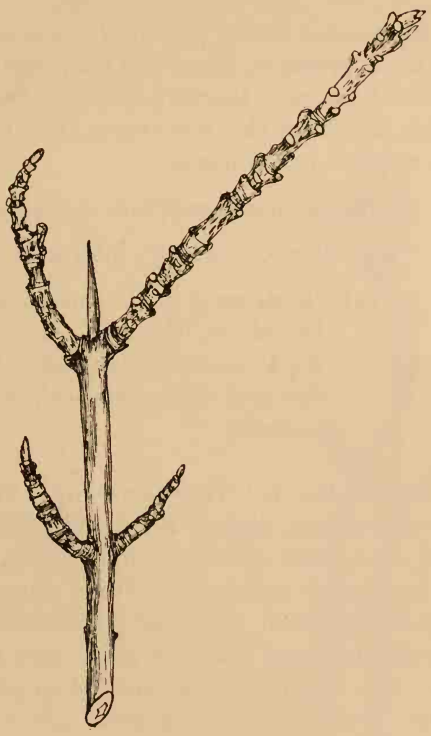


Fig. 77. Buckthorn, dwarf-shoots (D).

obscure leaf-traces; leaf-bases slightly prominent. Lenticels scattered and rather large, but more conspicuous on the branches. Pith small, irregularly round.

The first pair of bud-scales stand right and left: these are followed by about 6—7 pairs, of which only 4—5 pairs show on the outside, and then by young leaves with their stipules. The scales are primarily opposite, but the

inner tend to depart from this arrangement (Fig. 28). The outermost scale very frequently carries a bud in its axil.

The only similar thorny plant is *Prunus spinosa*, where the buds are aggregated, blunt and alternate (see p. 192); in the general aspect of the dark branches, pale epidermis, &c., it also simulates the Blackthorn, but the buds and leaf-scars are here sub-opposite.

(b) **Twigs never thorny; buds opposite and decussate.**

(i) Shrub, climbing; internodes long.

(*a*) *Buds very small and tomentose, nearly buried in the leaf-axil, and showing* 2—4 *scales only; petioles persistent, dry and stiffly extended, some acting as tendrils.*

Clematis vitalba, L. Traveller's Joy. The twigs are thin, six-angled, and slightly rilled and silky; internodes long and weak with abundant round pith. Bud-scales pointed, brown-red and hairy. Twigs olive-green, often tinged violet-red, with traces of pubescence, passing to grey or yellowish grey branches which cast the periderm in strips. The long plumed achenes often persist far into the winter, and explain the popular name "Old Man's Beard" sometimes given to the shrub. There is no other native hedge-plant with opposite leaf-tendrils.

(*β*) *Buds* 4*-angled, rapidly extended in spring and then almost fusiform, with numerous loose dry membranous-herbaceous scales, standing off at an angle of* 45° *or more. Pith hollow. Twining plant. Lenticels not obvious.*

Lonicera Periclymenum, L. Woodbine or Honeysuckle

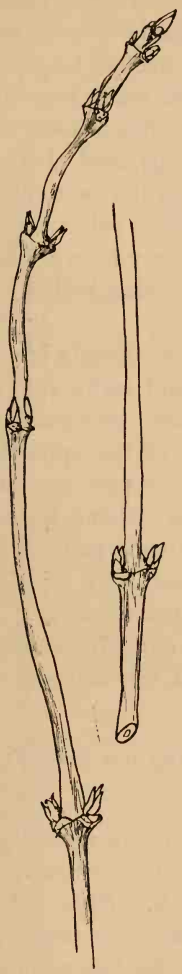


Fig. 78.

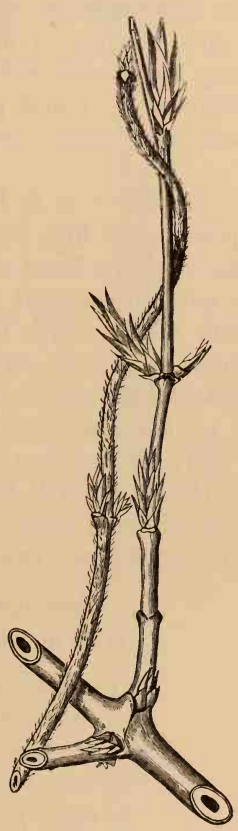


Fig. 79.

Fig. 78. Honeysuckle, *Lonicera Periclymenum* (D).
Fig. 79. Perfoliate Honeysuckle, *Lonicera Caprifolium*, p. 164 (Sc).

(Fig. 78). The buds are usually single, but may be several together, one above the other in each axil, the lowermost dominant, the apex of the shoot is usually aborted and has a pair of buds on the flanks. Scales keeled, long-pointed, brown and smooth. The twining shoots are pubescent, pale grey or tawny, and often with a bluish bloom near the tip.

The bud-scales are fairly numerous, and their sharp keels give the bud a distinct 4-angular section. The emerging leaves often red-violet. Twigs yellowish brown or leather-tawny, round, passing to grey-brown branches with torn and fibrous cortex. Internodes hollow: nodes solid.

The main axis of *L. Periclymenum* usually ends in a dead piece. The first bud-scales stand right and left of the axis, and are fused at their bases: this basal fusion is even more pronounced in the case of the opposite and decussate leaves which follow. The scales are narrow, triangular, acuminate, reduced leaves: about 4—5 pairs show outside, followed by about 4 further pairs of leaves inside, all decussate and fused below, and as the bud opens early the number of leaves appears large.

The closely allied *L. Caprifolium* (Fig. 79) has smaller buds, and different upper leaves, and the leaf-scars meet round the apex of the twig.

(ii) Plant neither climbing nor armed: twigs erect and stiff.

(*a*) *Buds naked; i.e. not covered by true scales, but exposing the ordinary leaves in their folded state. Buds relatively long and narrow, showing two opposite, erect, plicate leaves, the two minute bud-scales at the base being caducous; covered, like the shoot-tips, with mealy grey stellate hairs.*

Viburnum Lantana, L. Wayfaring Tree (Figs. 80 and 49). The buds are relatively large and somewhat appressed. Flower-buds fatter, slightly stalked, and ex-

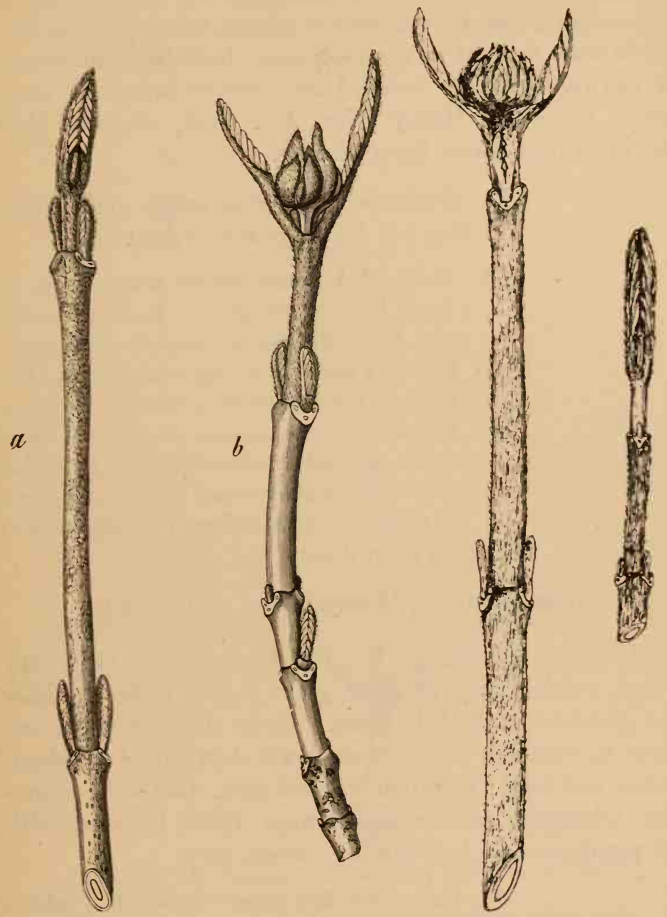


Fig. 80. Wayfaring Tree, *Viburnum Lantana*. *a* twig ending in a leaf-bud, *b* in a flower-bud (D and Sc).

panded depressed, covered with mealy scales and standing between two plicate young leaves. Older twigs tawny. Leaf-scars crescentic or shallow V-shaped; leaf-bases not prominent. Twigs with a tendency to be angular or striate, yellowish brown, with scattered inconspicuous lenticels more evident as the twig ages; branches pale brown or tawny, becoming fissured and greyer brown. Young leaves involute. Henry (Nov. Act. 1846) observed that the innermost leaves have stipules.

(β) *Buds covered by true scales, and neither they nor the twigs mealy grey.*

* Bud-scales numerous or several, i.e. at least 10—12, or more. Buds extended and loose, the sharply keeled scales opening very early in spring, and allowing the tips of the leaves to protrude, giving a frayed-out appearance to the whole. Basal scales dry and membranous, pale yellowish brown, those above more herbaceous, green or tinged violet, and downy. Twigs yellowish grey, downy.

[See note regarding Honeysuckles on p. 159.]

Lonicera Xylosteum, L. Fly Honeysuckle (Fig. 81). Twigs whitish grey or dirty grey, hollow inside, slender and glabrous or slightly hairy. Buds often in pairs, one above the other in the axils, the lower dominant. Periderm fibrous and torn. Terminal buds solitary. Bud-scales somewhat triangular, pointed and downy. Older branches with the periderm torn into fibrous masses, grey.

** Bud-scales few; not more than about 4—6 visible, at least on the lateral buds.

† Bud-scale apparently one only, of two fused scales completely investing the bud, which is slightly pedicellate, ovoid-pointed and somewhat flattened on the side next the stem, or bluntly 4-angled, smooth and glistening Twigs pale brown to yellowish grey.

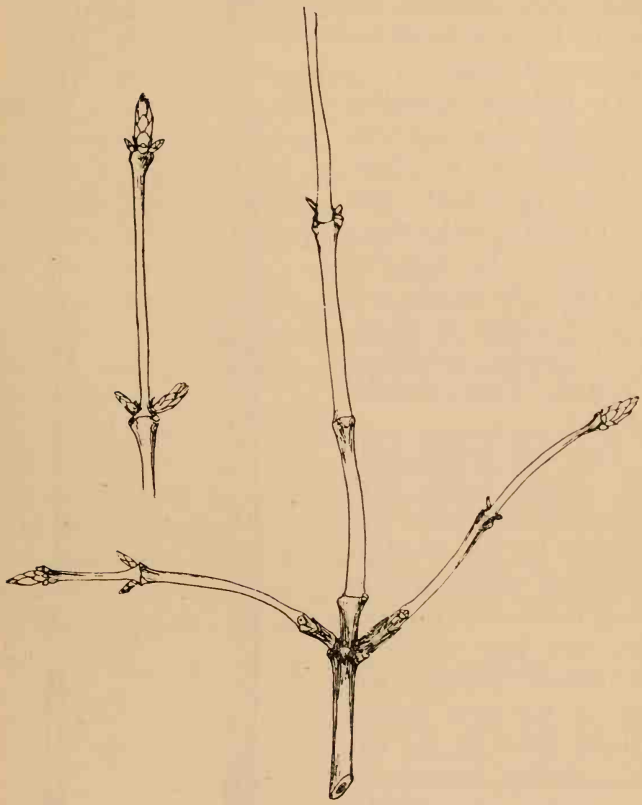


Fig. 81. Fly Honeysuckle, *Lonicera Xylosteum*, p. 166 (D).

Viburnum Opulus, L. Guelder Rose (Fig. 82). The terminal bud is usually aborted, a pair of lateral buds

flanking the tip. The covering consists of two fused scales, forming a reddish or greenish brown membrane sometimes split at the apex. The twigs are brownish or whitish grey, glabrous, and more or less angular above. Leaf-scars V-shaped.

The buds may be slightly viscid and shining red-brown, or greenish below. Leaf-base not prominent; pith nearly round or with a slight tendency to be 6-angled, large, pale. Twigs also with traces of angles or round, smooth, polished, pale brown to greyish. Lenticels small and few.

The bud begins with two opposite scales, right and left, showing their leaf-character by the venation, and closely united at their bases: these cover the rest. The next pair of leaves has minute stipules, and they or the next exhibit a slight notch at the top. Leaves further inwards are more or less normally developed.

The Willows are the only other shrubs with the

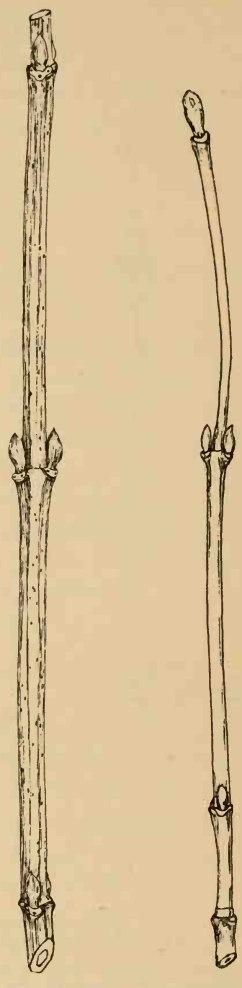


Fig. 82. Guelder Rose, *Viburnum Opulus*, p. 167 (D).

two bud-scales fused into one: they have alternate buds, &c., except in *Salix purpurea*.

†† Bud-scales at least 3 or 4; buds quite sessile.

⊙ *Twigs blood-red; buds small, slender, velvety pubescent and compressed, and showing* 3—4 *scales at most, sometimes apparently fused.*

Cornus sanguinea. Dogwood (Fig. 83). The bright crimson colour is at its best in spring, after the twigs have been exposed to frost, &c.: the older twigs and branches are grey. But the blood-red colour is not always developed, and the predominant colour of the twigs may be olive, touched with red; in these cases other characters will have to be relied on in diagnosis. Older branches olive-brown and fissured. The lenticels are not usually evident till the second year and sometimes spread out and fuse laterally, giving the branches an almost scaly appearance.

The very narrow and somewhat elongated, sessile buds, about 6—8 mm. long, may be appressed or not, and are often accompanied by an extremely small accessory bud below. Leaf-scars not prominent.

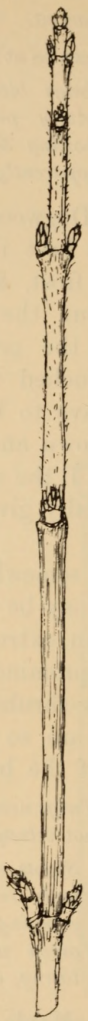
Several other hedge-shrubs have brown or reddish brown twigs, but none are so vividly blood-red, and all differ in the position of the buds, &c.

⊙⊙ *Twigs never brilliant blood-red, and buds not velvety.*

▱ *Shoots with white latex, and like the buds velvety pubescent; lateral buds exposing three scales only; bud-scales green with brown tips; older twigs tawny, corky.*

Acer campestre, L. Maple (Fig. 84). The terminal buds (often absent) are small, about 5 mm. long, and

Fig. 83.



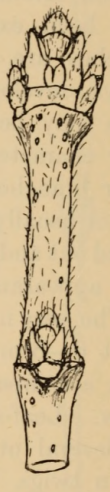


Fig. 84.

Fig. 83. Dogwood, *Cornus sanguinea*, p. 169 (D).
Fig. 84. Maple, *Acer campestre*. Shoot to right enlarged, p. 169 (D).

not essentially larger than the laterals, but may exhibit more scales. Twigs with pale fine longitudinal cracks, and the older often with pronounced corky ridges. Leaf-scars crescentic and meeting at their ends round the twigs as in *A. platanoides* (Fig. 59 *f*). The only similar cases are furnished by small twigs of *Acer pseudoplatanus*, where, however, both milky latex and corky ridges as well as pubescence are wanting: *A. platanoides* has the milk but no hairs. Moreover the terminal bud of both is larger.

In *Acer campestre* the leaf-bases project slightly, and the buds are nearly erect and appressed; bud-scales with whitish cilia, and twigs often, but not always, pubescent at the tips, elsewhere polished olive-green or leather-yellow to tawny, with numerous but minute lenticels. Older branches greyish and fissured, or, if corky, tawny red-brown.

The bud-scales are leaves. The outer 5—6 pairs exhibit a gradually more distinct venation, while the sixth to eighth pairs show the lobing of the lamina and typical venation. The scales and their scars are conjoined at the edges, and are narrow crescentic. The transverse section of the bud is rhomboidal, owing to the keels of the decussate scales.

▱▱ *Tissues devoid of latex; twigs not tawny and corky; buds glabrous.*

§ *Buds ovoid-pointed, more or less* 4*-angled and green, appressed. Twigs matt-green with* 4 *equidistant thin ridges.*

Euonymus europæus, L. Spindle Tree (Fig. 85). The matt-green of the twigs, which are bitter to the taste, may pass to violet-green, or brownish, to olive, and the 4 slender ridges render them more or less quadrangular.

The green bud-scales also are touched with red at the margins and tips. Leaf-scars minute, somewhat promin-

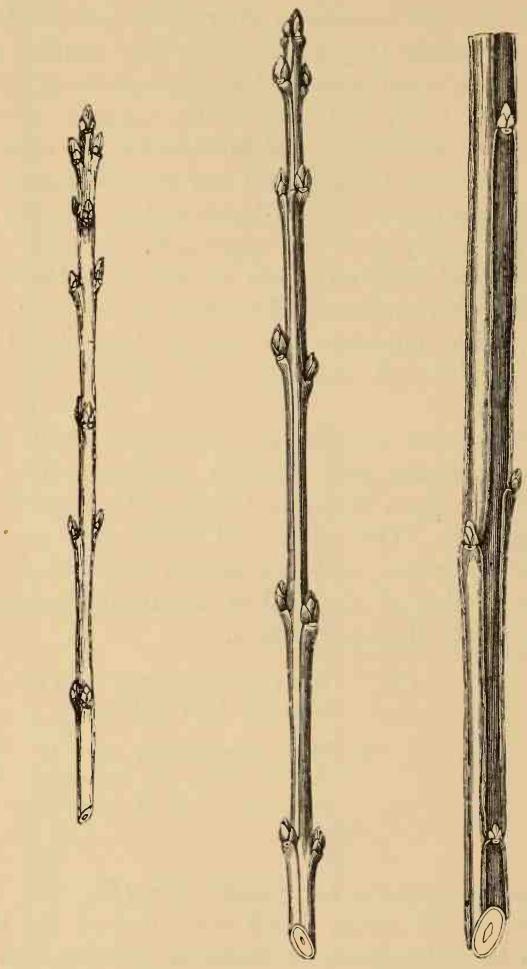


Fig. 85. Spindle Tree, *Euonymus europæus*, p. 171 (D and Sc).

ent, semi-circular or lunate, with a crescentic leaf-trace. The bud-scales are green, but dry and membranous, ciliate, and bordered with brown; and the twigs may be somewhat flattened at the tip.

§§ *Twigs and buds neither decidedly green, nor markedly 4-angled or ridged. Leaf-scar small, with one crescentic leaf-trace.*

‡ *Buds very minute, 1—4 mm. or so long, showing about 4 scales, which are keeled and flattened, and purplish green; twigs greenish grey or tawny; no ridges.*

Ligustrum vulgare, L. Privet (Fig. 86). The leaves may persist through the winter, the shrub being sub-evergreen (see p. 144). The twigs are smooth, olive-grey passing to brownish, with few scattered lenticels, more prominent on the grey branches. Occasionally the dwarf-shoots are developed in whorls of three. Leaf-scars almost elliptical, with one crescentic leaf-trace, as in the Lilac (Fig. 59 *r*). Bud-scales varying from 4 to 6, greenish with deep brown apex, and slightly ciliate.

The terminal bud has narrow scales. The bud begins with two scales, right and left, soon pushed apart by the 4—6 inner pairs of pointed, decussate, inner ones, which gradually pass into ordinary leaves at about the sixth pair.

‡‡ *Buds usually with two minute lateral ones in axils of lower bud-scales; branches with silky fibrous periderm.*

Symphoricarpos racemosus, Mchx. Snowberry. Twigs pale grey, passing to brownish, hollow at the internodes, glabrous. Buds very minute, on somewhat prominent leaf-bases, the latter joined across the sides of the twig by a narrow ridge or line.

It may be noted here that sub-opposite buds occur on the twigs of *Salix purpurea*, but they have one bud-scale only.

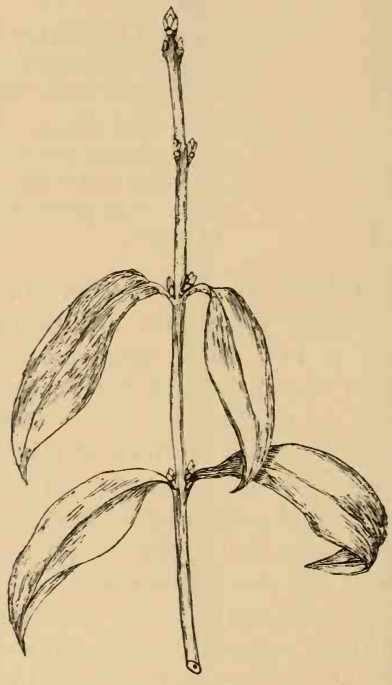


Fig. 86. Privet, *Ligustrum vulgare*, p. 173 (D).

B. BUDS ALTERNATELY DISPOSED ON THE TWIGS. [Sub-opposite buds occur on the twigs of *Salix purpurea*, and may be accidental elsewhere.]

(1) **Buds distichous, at any rate on the long lateral twigs, usually more or less displaced to one side of the leaf-axil towards the upper side of the horizontal shoots; the terminal**

bud usually aborted, and replaced by the next lateral one. Scales stipular.

[The distichous arrangement frequently disappears and runs into a spiral on erect or dwarf-shoots.]

(a) **Buds narrow and relatively long, pointed, about four to six times as long as broad, exposing numerous scales, imbricated in several spiral series, tawny or greyish; twigs slender, more or less zig-zag.**

(i) Buds about 2 cm. long, fusiform; twigs strongly zig-zag.

Fagus sylvatica, L. Beech (Figs. 87 and 16, 26, 43, 50 and 51). The long slender twigs have the buds standing off at an angle of 60°—70°. Bud-scales stipular, numerous, tawny or greyish, slightly ciliate at the tips, and imbricated in a spiral so slight that they are nearly distichous. The lateral buds are slightly displaced to one side of the small leaf-scars, and the terminal bud is frequently aborted. Dwarf-shoots ringed with the scales of more spirally arranged leaves, with no buds in their axils. The buds are thickest about one-third up. Scales pale brown with darker markings or margins, thin and membranous, ciliate. Leaf-scar small and nearly elliptical, with 3 minute leaf-traces. Twigs smooth and polished, or nearly so, olive-brown, pale greyish brown, darkening with age. Lenticels numerous, more distinct on branches. Pith rounded, greenish.

In the autumn the tips of the shoots cease to form leaves, but continue to develop stipules which act as bud-scales. In the bud the outermost of these are broad and short, pointed and membranous, but further inwards we find them longer, narrower and more delicate in texture. The margins are finely ciliate. The first 7—8 pairs are

devoid of any trace of leaves, then follow several pairs with incipient leaves between them, while the interior of

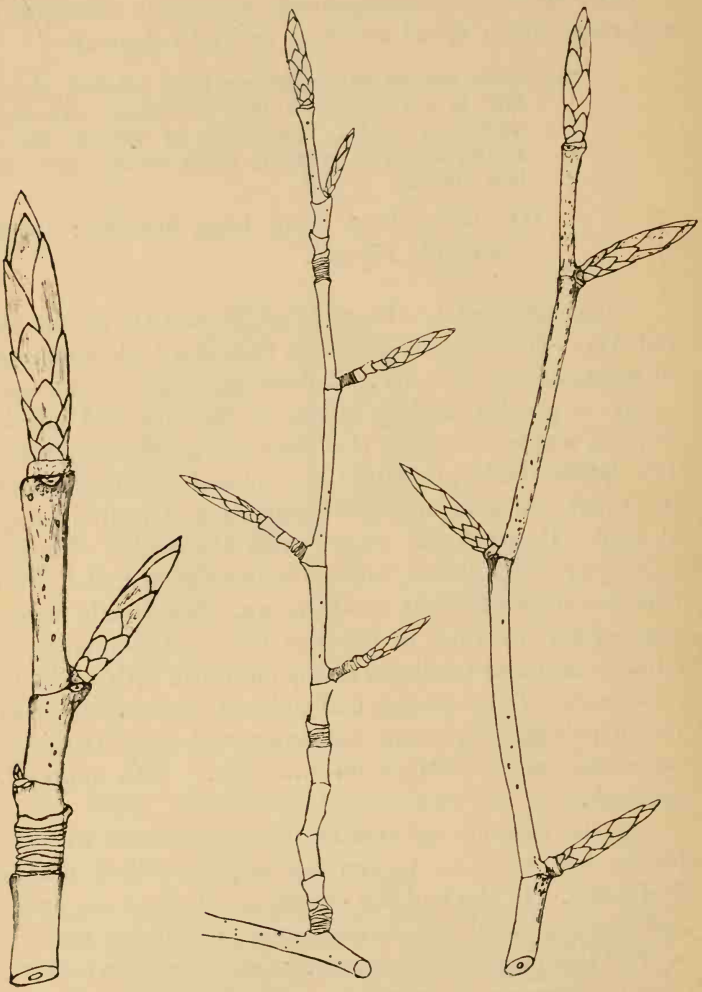


Fig. 87. Beech, *Fagus sylvatica*, p. 175 (D).

the bud shows normal, plaited, stipulate leaves, densely covered with silky pubescence, their inner faces turned towards the axis of the bud. The position, mode of covering, &c., are similar to those of *Castanea*, *Corylus* and *Tilia*, but with considerable differences in details of structure.

The first two scales, right and left of a plane oblique to the axis, are followed by distichous pairs of scales alternately right and left, and so on until the leaves, also distichous, appear. The spiral differs from that of *Corylus* and *Castanea*.

(ii) Buds only about 1 cm. long, oblong-acuminate, and slightly angular, and much more appressed to the slightly zig-zag twig.

Carpinus Betulus, L. Hornbeam (Figs. 88 and 89 and 59 *u*). Besides being shorter and relatively fatter than those of the Beech, the buds and shoots are somewhat more pubescent, and the latter more olive. A second, accessory bud frequently accompanies the primary one, and may also put forth a shoot. Slight displacement of the bud from the axil also occurs here. Scales stipular. Twigs with scattered hairs, olive-brown, passing to dark slaty grey branches. Lenticels distinct; pith angular. Bud-scales brown, ciliate and pubescent at the tips. The terminal bud usually aborted. Structure as in the Beech but the spiral differs.

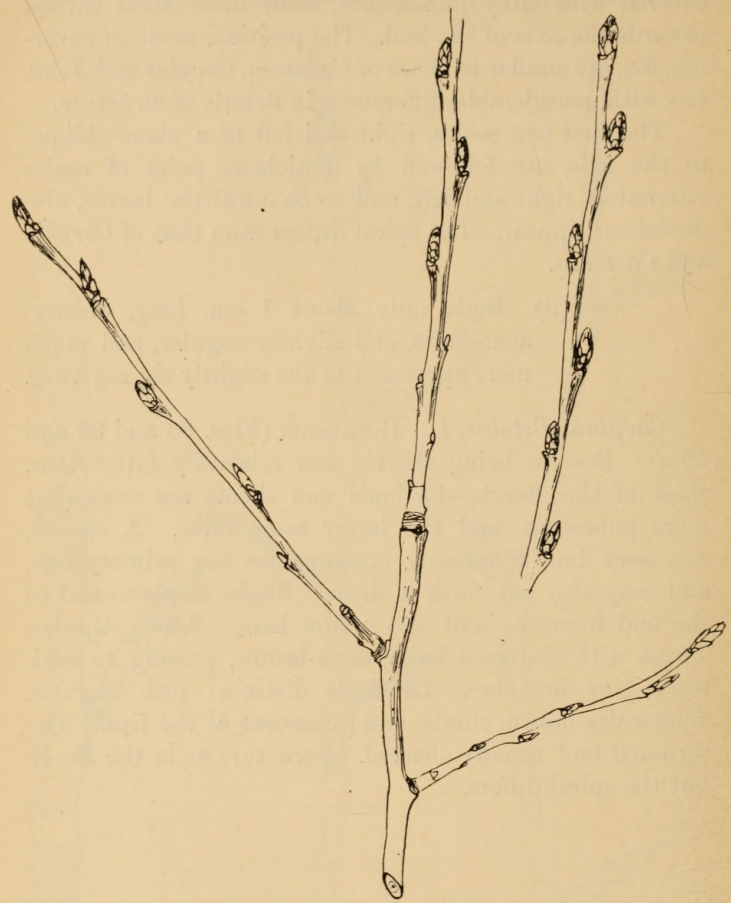


Fig. 88. Hornbeam, *Carpinus Betulus*, p. 177 (D).

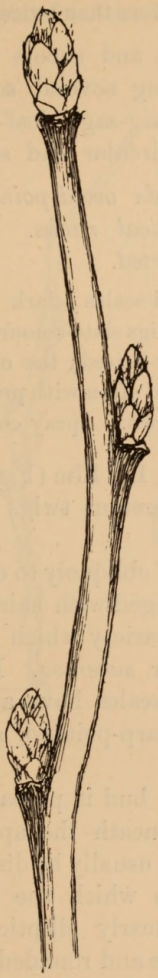


Fig. 89. Hornbeam, twig and buds enlarged (D).

(b) Buds short and stout, more or less ovoid or conoid, and not more than twice as long as broad.

(i) Buds and shoots pubescent, the former exposing several scales, the latter somewhat zig-zag: leaf-bases and scars small, semi-circular and somewhat prominent.

(*a*) *Buds ovoid-pointed, the scales in two vertical ranks. Terminal bud always aborted.*

* Bud-scales dark brown, nearly black; twigs slate-coloured or greyish, not glandular-haired; the older twigs finely fissured and often with prominent cork-ridges lower down. Spray curved, not pendent.

Ulmus campestris, L. Elm (Figs. 90 and 15, 29). The spray usually has numerous twigs curving away from the apex.

The buds stand off obliquely to one side of the leaf-scar, and the scales are fringed with hairs, which are simple and not glandular. The variety which forms thick cork-ridges is often known as var. *suberosa*. In some varieties—e.g. var. *effusa*—the bud-scales have a darker brown margin and the buds are sharp-pointed, and like the branches glabrous.

The true terminal bud is probably always abortive, its scar being visible beneath the apparently terminal one, and stipular scars can usually be distinctly made out flanking the leaf-scars, to which the bud is oblique. Each leaf-scar, which is nearly elliptical, bears 3 leaf-traces (Fig. 59 *m*). Pith pale and rounded. Twigs bright reddish or yellowish brown passing to olive-brown.

In the bud one outer scale overlaps its opposed scale at the edges, and is followed by about 6—8 further such

distichous scales, but the whole series is twisted slightly to one side of the axis, and in the flower-buds the inner-

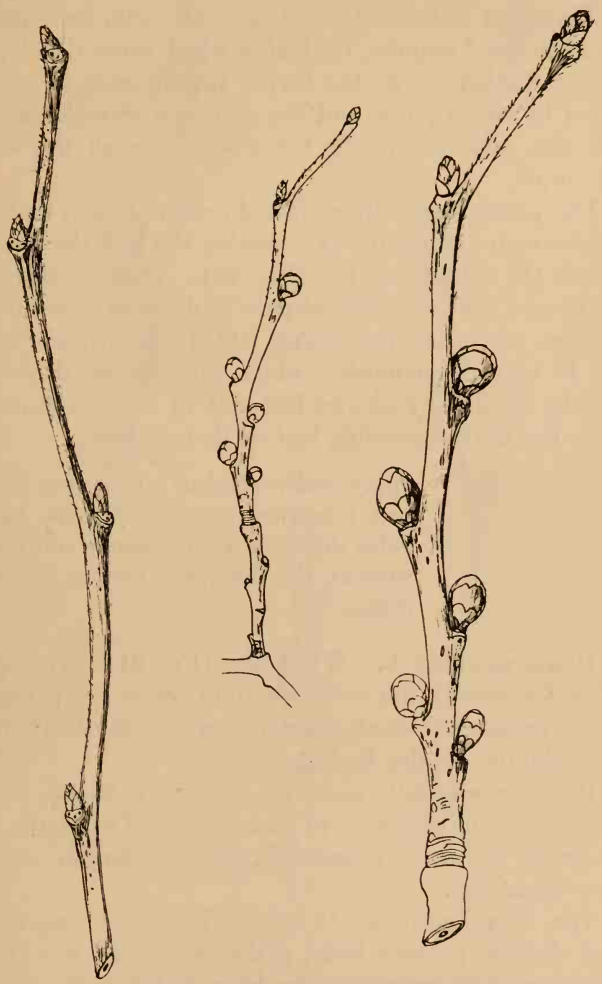


Fig. 90. Elm, *Ulmus campestris*. The larger rounded buds are flower-buds, p. 180 (D).

most scales gradually pass into a spiral arrangement, which is not the case with the purely foliar lateral buds.

There can be little doubt that each outer scale represents two fused stipules, the leaf of which is not developed; because further in, as the leaves appear, each is accompanied by two stipules, and the sequence of scales agrees with this assumption. In the flower-buds all the scales are simple.

The young leaves are so folded (conduplicate) that the margins turn towards the axis bearing the bud, the midribs towards the subtending leaf (Fig. 29). Their stipules are so arranged that each first stipule is directed towards the axis and covers its own young folded leaf—whose dorsal side is turned outwards—while the second stipule is partially covered by its own leaf and, in its turn, partially covers the next succeeding leaf on its own side.

** Spray stiffly pendent; buds grey-brown and somewhat larger and more hairy; twigs the same colour, stouter and rough, without the fine pale fissures or cork-ridges.

Ulmus montana, L. Wych Elm (Fig. 91). The spray makes few curves, the twigs standing off at sharp angles, and is usually directed slightly downwards, stiffly, in a plane oblique to the horizon.

Buds brown, with more or less rusty hairs. Twigs fairly stout, olive-green to red-brown. Leaf-scars and leaf-traces as in *U. campestris*, but the former usually more triangular.

The Elm known as *U. effusa*, Wild, has longer and more sharply pointed buds, glabrous, as are the twigs; also larger leaf-scars, and the bark scaly.

The Elms present difficulties to the beginner owing to

certain resemblances to the Hornbeam and the Hazel. The

Fig. 91. Wych Elm, *Ulmus montana*. Twig to the left above enlarged, p. 182 (D).

former is at once distinguished by its more fusiform buds and spiral scales; the latter by its fatter and more rounded buds and glandular hairs. In the last resource—i.e. if the very different leaves, flowers and fruits are inaccessible—the wood of the Elms has large vessels in the spring wood and tangential bands of parenchyma in the autumn wood, both wanting in transverse sections of Hornbeam and Hazel.

There is still considerable difficulty about the various sub-species or varieties of Elms, but *U. campestris* has the twigs and buds practically smooth; while in *U. montana* both are stiffly hairy. In both the bud-scales are uniformly brown. In the var. *effusa*, the twigs are glabrous, but the buds, which are sharp and hard pointed, have pale brown scales with an almost black ciliated margin.

(β) *Buds rounded-ovoid, obtuse, with several broad glandular-ciliate scales, spirally imbricate; twigs glandular, hairy.*

Corylus Avellana, L. Hazel (Fig. 92). The buds are somewhat compressed, hardly displaced to one side of the projecting leaf-scar; bud-scales tawny or greenish to brownish, and fringed with reddish glandular hairs and cilia; the pedicel of the male catkins, usually discoverable in winter, particularly glandular. Twigs olive-brown, the lenticels obscure, but visible on the smooth brown branches. The female flowers are in buds, very similar to the ordinary ones, but fatter, and the crimson stigmas protrude in early spring.

The internal arrangement of the parts of the bud is the same as in the Chestnut, but the leaves are conduplicate with the margins turned towards the parent axis as in the Elm.

(ii) Buds with only 2, or at most 3, scales exposed, and like the twigs glabrous or nearly so; fat ovoid and hardly pointed, olive to brown-red or purplish.

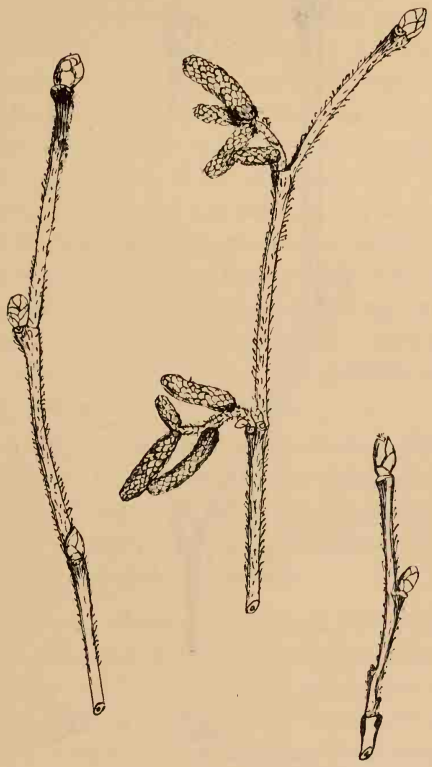


Fig. 92. Hazel, *Corylus Avellana*, p. 184 (D).

(*a*) *The second or third scale completely embracing the rest; twigs cylindric, olive-green or red, with small scattered lenticels. Pith round and white. Leaf-scar semi-circular with one crescentic leaf-trace.*

Tilia europœa, L. Lime (Figs. 93 and 31). Spray flat, with some of the twigs recurved in one plane. Buds

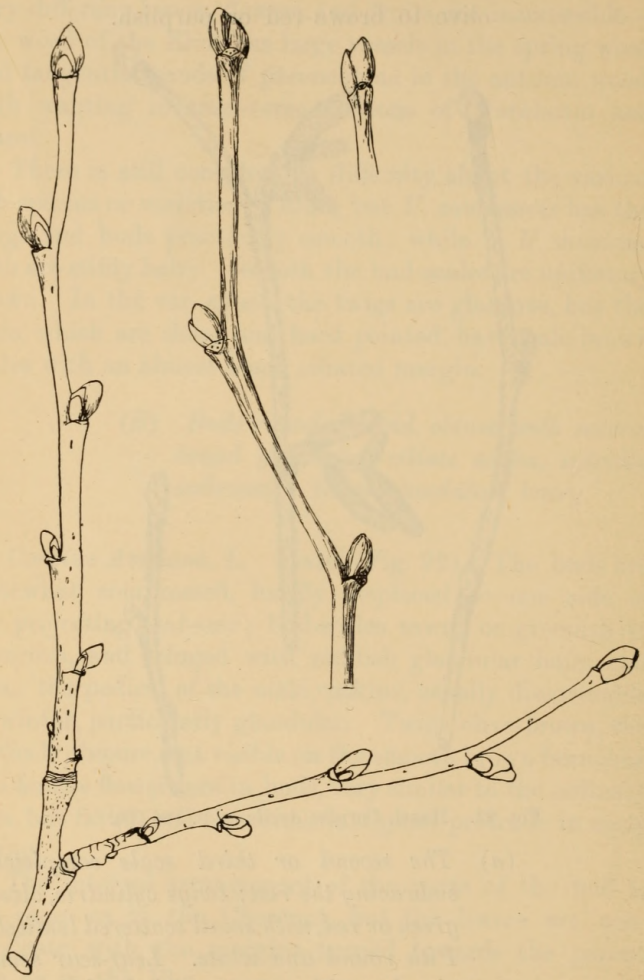


Fig. 93. Lime, *Tilia europœa* (D).

rather fat, standing off and obliquely displaced to one side of the small leaf-scars. Twigs zig-zag, dark red passing to greenish grey: young shoots pubescent in summer.

The variety *T. parviflora* has glabrous yellowish brown twigs, somewhat more slender than var. *grandifolia*.

The terminal bud appears to be always aborted, and the lateral buds are displaced to one side of the axil. The most external bud-scale is lateral, and covers the one distichously opposed to it at the margins. These scales must be looked upon as fused pairs of stipules, since there now follow in distichous sequence conduplicate leaves, the margins of which are turned towards the axis bearing the bud, each with a pair of stipules covering its outer face (Figs. 24 and 31 *c*). There is usually a microscopic bud in the axil of the second scale. The general arrangement is much the same as in the Hazel.

(*β*) *Buds showing* 2 *scales, yellowish green touched with red or grey; shoots angular; leaf-scar fairly large rounded-triangular, with* 3 *groups of leaf-trace bundles; pith angular, greenish.*

Castanea vesca, Gaertn. Chestnut (Figs. 94 and 59 *p*). The pseudo-terminal bud usually larger than the rest. Twigs olive to red-brown, faintly pubescent or glabrous, passing to rough grey, and with conspicuous lenticels. Dwarf-shoots numerous. Leaf-bases prominent, with decurrent lines.

The bud commences with two outer scales, right and left, each of which must be regarded as two-fused stipules. Then follow, in distichous sequence, a pair of stipules with or without a leaf-rudiment between them, then several pairs of stipules, each pair covering the dorsal surface of

its own slightly plicate, but hardly folded leaf, the inner face of which lies on the younger stipules and leaves inside. The plaiting of each leaf follows its principal veins: the margins are turned forwards and the surface is finely hairy. The stipules nearest the axis overlap the margins of those nearest the subtending leaf.

Betula, the Birch, in which the buds are predominantly spiral, sometimes shows a tendency to have distichous buds (see p. 233).

Vitis, the Vine (Fig. 25), and *Ampelopsis*, easily known by their knotted long twigs, with prominent leaf-bases and nearly circular leaf-scars, with frequent tendrils leaf-opposed, also have their stumpy conical glabrous buds, with few scales, arranged in a more or less distichous manner.

The terminal bud of the Vine is rarely developed, the tip of the shoot usually dying off. The lateral buds

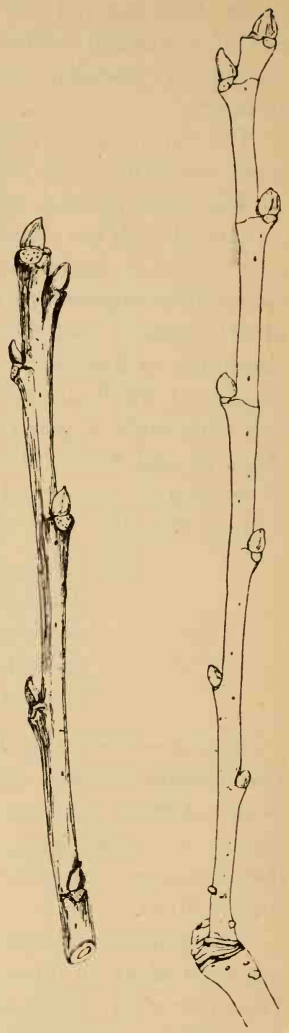


Fig. 94. Chestnut, *Castanea vesca*, p. 187 (D).

are distichous with a slight displacement to one side. The bud-scales are stipules.

The Vine bears two kinds of shoots, long shoots and dwarf-shoots, and considerable differences in detail occur according as the former bear leaves and flowers or flowers only.

Taking the case of a non-flowering shoot. It begins with two small basal scales close together, one on either side of the axis, then come a large number of foliage leaves, alternate and distichous: there may be as many as 40 of these, each with a dwarf-shoot bud in its axil. The lowest 3—5 appear without tendrils, thence onwards (with considerable regularity, though not without exceptions) of every three nodes the lower two bear each a tendril and a leaf, while the third bears a leaf only, so that the tendrils appear in alternate pairs and each opposite a leaf.

Each bud in the axil of a leaf on the long shoot begins with a lateral scale, the margins of which overlap an apposed leaf with its two stipules: the latter in turn overlap a similar leaf with its two stipules, opposite which leaf is a tendril, and so on in distichous order. In the axil of the lateral scale we began with is another bud, this time that of a long shoot.

The Planes (*Platanus*) have also practically distichous leaves on the long lateral twigs (see p. 213).

(2) Buds spirally arranged on the twigs, or at any rate not simply distichous, or displaced with respect to the leaf-scars.

[See note regarding the Birch, Vine, *Ampelopsis* and Plane, on p. 188.]

(a) Twigs armed with spines, thorns, or prickles.

(i) The spines originate in leaf-axils or terminate the twigs of which they are

the hardened apex: i.e. they are true thorns, often themselves bearing buds and leaves.

(*a*) *Shoots and twigs slender and green, with sharp spines prominently in evidence, and obscuring the minute buds and leaf-scars. Small, much branched bushes.*

* Twigs round glabrous; spines slender, recurved, simple or rarely branched, 1½—3 cm. long, glabrous.

Genista anglica, L. Petty Whin. The lower parts and flowering twigs may be spineless. Twigs covered with brown membranous skin, and striate when young. The spines are true branch-thorns.

** Twigs green, rilled and velvety, as are also the branched thorns which are 3—6 cm. or more long.

Ulex europæus, L. Furze, Gorse. As already stated on p. 145 the Gorse is evergreen as regards its branch system, but the minute leaves soon fall or are developed as spines. It is a larger shrub than *Genista*, and velvety pilose, otherwise with resemblances to the latter. The same applies to *U. nana*.

(*β*) *Twigs woody, bearing stout spines, less numerous and prominent, and the buds and leaf-scars more in evidence.*

* Buds and twigs bronzed with shining silvery or coppery scaly hairs; buds obovoid, lobed or depressed at the apex; showing two concavo-convex scales; spines simple, sharp, from the leaf-axils or terminal. Leaf-scar very small with one minute leaf-trace.

Hippophaë rhamnoides. Sea Buckthorn (Figs. 95 and 59 *s*). The bronzed twigs are angular and nodose with

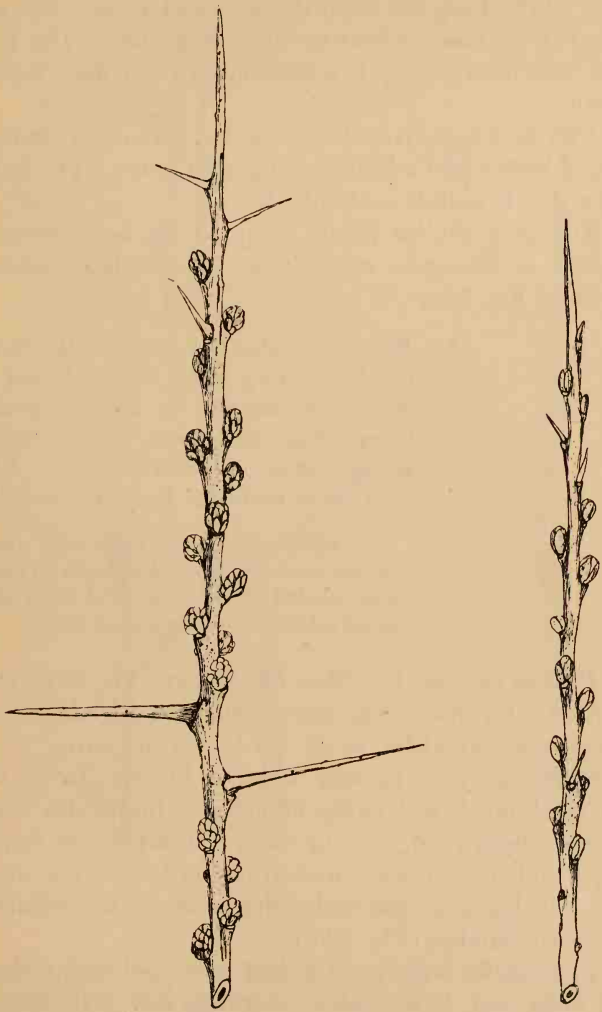


Fig. 95. Sea Buckthorn, *Hippophaë rhamnoides* (D).

rather prominent leaf-bases bearing minute semi-lunate or ellipsoid leaf-scars, each with a single minute leaf-trace (Fig. 59 *s*). They are often thorny dwarf-shoots each with a bud on its base, or bearing clusters of buds. The twigs pass from matt-silvery to glistening olive or dark reddish brown.

Pith brownish, irregularly angular. No other similarly shaped buds—like a heart—are known to me. The bronzing is due to peltate scale-like hairs.

The only similar plant, likely to be encountered in gardens, is *Elæagnus angustifolia*. Its stellate scales are shown in Fig. 55 *e*.

** Buds and twigs not bronzed, the former not lobed, very small, rounded, and the latter not angular or nodose: branch-thorns rigid and hard, usually bearing several buds and leaf-scars, the latter with more than one leaf-trace bundle.

† Shoots pubescent, twigs when fully ripened shining brownish black; leaf-scars very small and rounded; buds minute and often aggregated side by side in groups of three.

Prunus spinosa, L. Sloe, Blackthorn (Fig. 96). Buds about 1—1·5 mm. long, sub-globular, and glabrous, the shoots often greyish; twigs red-brown or, owing to the epidermis, greyish, passing towards black. Twigs slim and rigid, much and stiffly branched. Bud-scales nearly glabrous, brown-red, pale or dark. Dwarf-shoots densely ringed and often crowded with groups of buds. The nearly elliptical leaf-scar generally shows three approximated leaf-trace bundles (Fig. 59 *q*).

P. insititia, with stouter and more pubescent shoots and buds, and *P. domestica*, thornless and with browner

twigs, are forms passing into the less spinose varieties of *P. spinosa*. They present difficulties owing to their

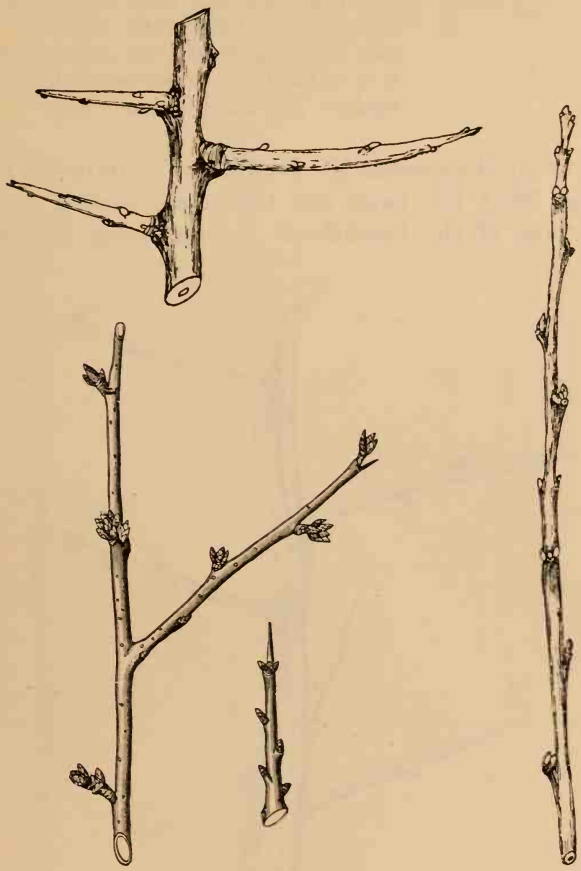


Fig. 96. Blackthorn, *Prunus spinosa*, p. 192 (D and Sc).

resemblances to *Rhamnus*, but the buds and leaf-scars in the latter are sub-opposite or opposite (see pp. 159, 160).

†† Shoots glabrous, and twigs silvery grey to dull brown; leaf-scars crescentic, small, with 3 leaf-traces; buds minute, the terminal not more than 0·5 cm. long, and often two together, one larger than the other and soon dying; pairs also are common at the base of the thorn, which is stout, smooth, straight, and about 1—2 cm. long.

Cratægus Oxycantha, L. Hawthorn, Whitethorn (Figs. 97 and 98). The twigs and thorns are usually stouter than those of the Blackthorn, besides being greyer or

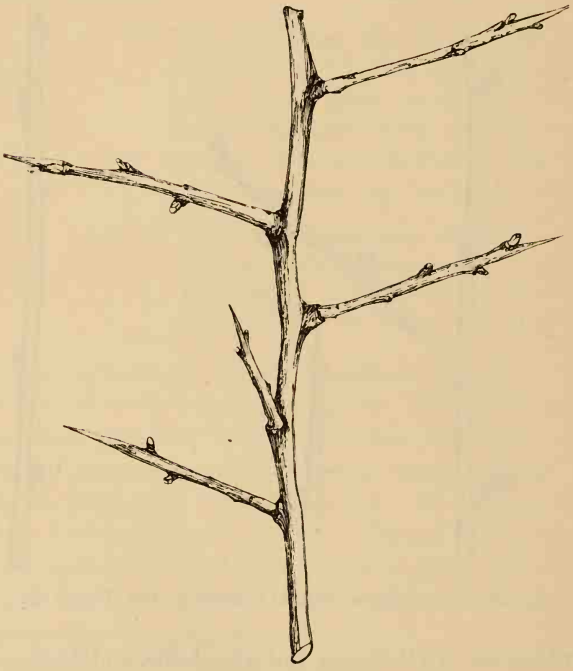


Fig. 97. Hawthorn, *Cratægus Oxycantha* (D).

browner and less polished. The buds also are larger and

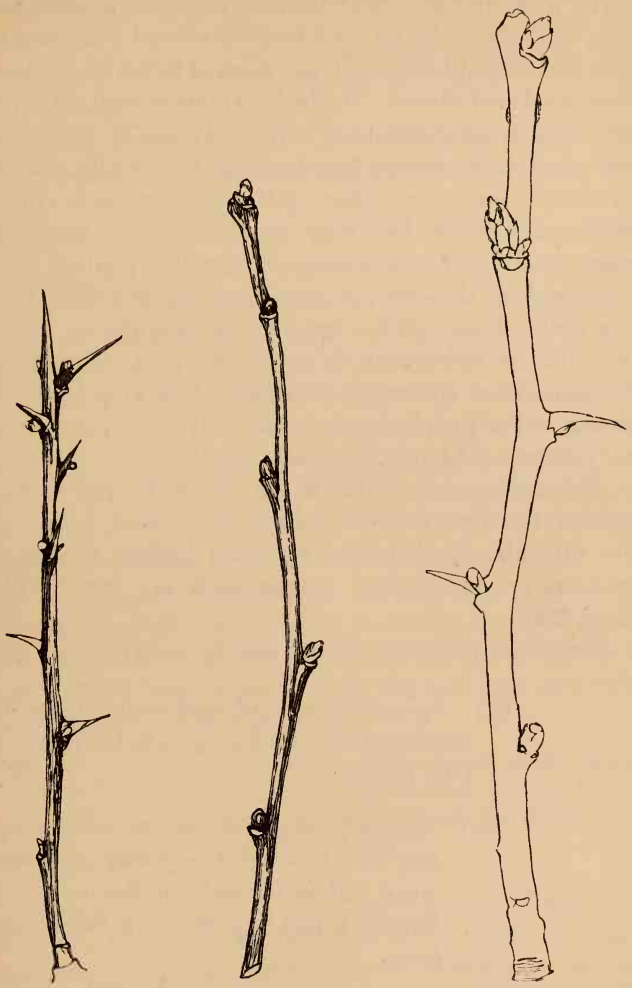


Fig. 98. Hawthorn, *Cratægus Oxycantha*. Shoot to the right enlarged, p. 194 (D).

slightly angular. The thorns are of two kinds, shorter thorns without leaf-scars but often with two minute basal buds, and longer stouter ones bearing several leaf-scars and buds, and ringed below with the scars of fallen bud-scales—these are dwarf-shoots. The buds exhibit several scales, and are short ovoid-pointed, or conic. Traces of pubescence may occur on the shoots, but the twigs are usually glabrous. Periderm close to the surface; pith small, greenish. Thorns usually numerous, but may be absent from the longer twigs, or altogether wanting. Bud-scales reddish brown or greenish at the base, pointed, smooth, and with traces of a keel. Twigs with a tendency to angularity towards tips, olive to red-brown, or sometimes grey owing to the glistening loose epidermis, passing to dark grey (but other colours, red or purple-brown, and even yellow, occur) and finely striate. Lenticels few and small.

Pyrus communis, which is sometimes thorny owing to some of the dwarf-shoots ending in a hard point, may offer difficulties; there are no short leafless thorns, the leaf-scars are lunate, and the lenticels are more evident (see p. 239).

Mespilus Germanica should also be noted here.

(ii) Spines not axillary and never themselves bearing buds or leaves: i.e. they are not true thorns.

(*a*) *Spines closely flanking or subtending a leaf-base bearing a leaf-scar, and which has a bud in its axil; or themselves close beneath a bud: i.e. they are foliar structures.*

* Spines arising from the persistent base of the leaf, which bears a leaf-scar.

† Spines in pairs, one on each flank of the large and angular leaf-scar, sharp, rigid, compressed or angular and slightly curved upwards; buds minute, 2—5 together, buried in the prominent pulvinus.

Robinia pseudacacia, L. Robinia, False Acacia (Fig. 99). The spines are stipules and persist for several years; but they may be absent.

The twigs of *Robinia* are more or less 5-angular, brittle and long, and with conspicuous lenticels. In the cavity of the leaf-axil are really 2—5 superposed buds, minute, naked, and walled in all round by the up-growing pubescent margins of the petiolar base, which covers them entirely except for a small aperture above: the uppermost bud alone grows out as a rule, the lower may burst through the tissues of the leaf-scar itself, which is more or less shield-shaped, or trefoil-shaped, with 3 obscure leaf-traces. Pith pentagonal, pale. Twigs olive or brown to bright red-brown, passing to grey or slaty grey.

Platanus and *Philadelphus* are the only others likely to occur in which the leaf-bud is totally invested by the leaf-base, and they are easily differentiated, the former by its prominent buds exposed when the leaf falls, the latter by its opposite leaves and buds.

†† Spines triple, or occasionally single, beneath the small lunate leaf-scar and not flanking it; the leaf-scar subtends the single, prominent pointed bud.

Ribes Grossularia, L. Gooseberry (Fig. 100). The spines are borne on the pulvinus of the leaf, and sometimes there are other prickles, more bristle-like and not connected with the leaves, scattered along the internodes. Buds with several distinct but narrow, loose, brownish,

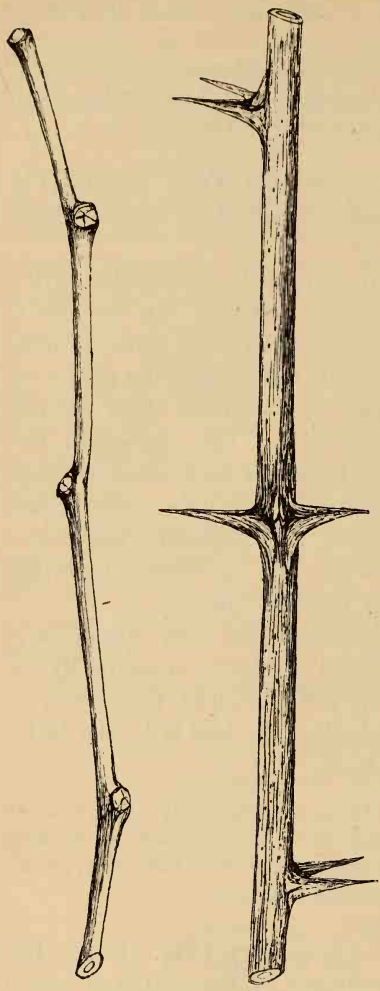


Fig. 99.

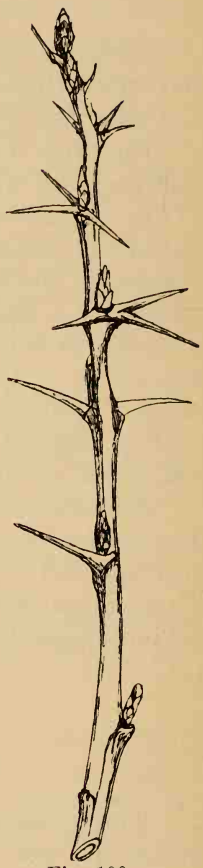


Fig. 100.

Fig. 99. Robinia, *Robinia pseudacacia*. To the left a spineless long shoot, p. 197 (D).

Fig. 100. Gooseberry, *Ribes Grossularia*, p. 197 (D).

ciliate scales; twigs slender, grey, with torn remains of the epidermis. Pith rounded. Shoots with dark hairs. Branches grey to brown, with peeling epidermis.

** Spines 1, 3 or 5-partite, not flanking or subtending a leaf-scar, but bearing the obtuse buds directly in their axils.

Berberis vulgaris, L. Barberry (Fig. 101). The tawny yellowish spines are metamorphosed leaves and are usually tripartite and somewhat lax, with slightly decurrent membranous insertion. Buds short and stumpy, the outermost scales evidently persistent leaf-bases, brown. The buds are in reality naked, i.e. composed of leaves in an embryonic condition, and not of true scales, though surrounded by leaf-bases. Each small nearly elliptical leaf-scar bears 3 minute approximated leaf-traces. Pith small, round, and pale. Twigs tawny or grey, bright yellow inside. Spines may be lacking towards the ends of the long shoots, or they may be simple. Branches grey-white to grey-brown, with fine fissures.

(β) *Spines in no way associated closely with the leaf-bases or scars, but scattered on the internodes, and superficial; i.e. they are neither foliar nor branch-structures, but prickles.*

* Prickles recurved, dilated, and compressed at the base, like cats' claws.

† Buds fat, ovoid, glabrous, blunt; twigs cylindrical, smooth; leaf-scars narrow, crescentic, with 3 leaf-traces.

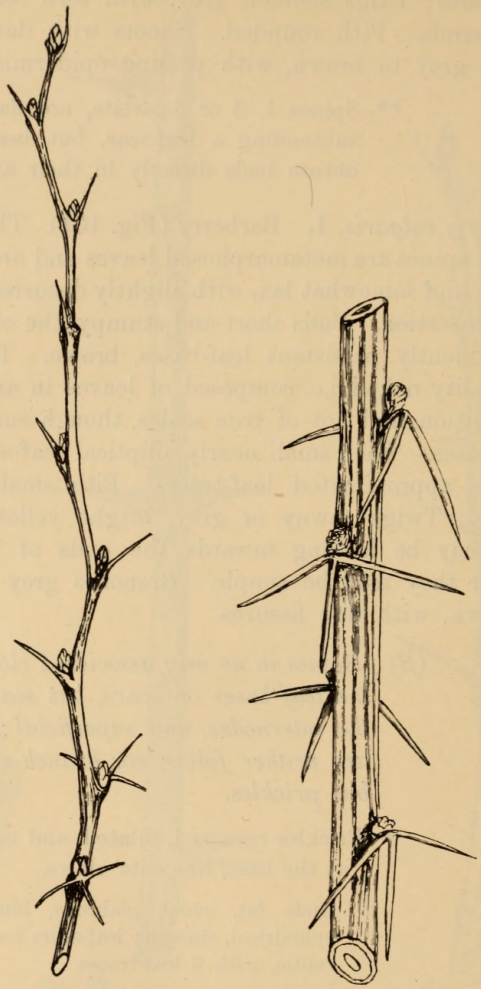


Fig. 101. Barberry, *Berberis vulgaris*, p. 199 (D).

Rosa canina, L. Dog Rose (Fig. 102). The species is here accepted in the wide sense; specialists divide it up

Fig. 102. Dog Rose, *Rosa canina* (D).

into numerous forms impossible to define here. The ordinary long shoots are flung over hedges, &c. in large arcuate sweeping curves, and are green touched with red and violet, passing to grey. The suckers are straight and erect, weak, and full of pith. There are commonly two prickles near together beneath each node. Leaf-bases not prominent. Buds closely imbricate.

Other species of *Rosa* are, *R. rubiginosa*, Sweet Briar, Eglantine, with curved prickles and glandular hairs; and *R. arvensis*, Field Rose, much like *R. canina* but more trailing, &c.

†† Buds long, pointed, with loosely imbricated hairy scales; twigs angular; leaf-base projecting and scar oval.

Rubus fruticosus, L. Blackberry, Bramble (Fig. 103). Here, again, the species is cut up by specialists into numerous sub-species and varieties impossible of treatment here. The long arcuate shoots are flung over hedges, &c., and frequently root at the tips, and are green touched with violet-brown or red. There are sometimes two buds in the axil, and the subulate stipules may remain attached to the leaf-base. In some cases the leaves remain throughout the winter, and the plant is sub-evergreen.

Rubus Idœus, the Raspberry (Fig. 104), has thinner, more rounded and erect shoots, with thinner and straighter prickles, or none, and touched with a bluish bloom. Buds greenish to olive-brown, standing out on projecting leaf-bases, bearing narrow crescentic leaf-scars, showing 3 leaf-traces. Bud-scales keeled and ciliate. There are often 2 buds superposed, the upper dominant. Twigs often contorted and striate, rounded, tawny yellow to greenish brown or olive.

** Prickles straight or nearly so, mingled with bristles and glandular hairs.

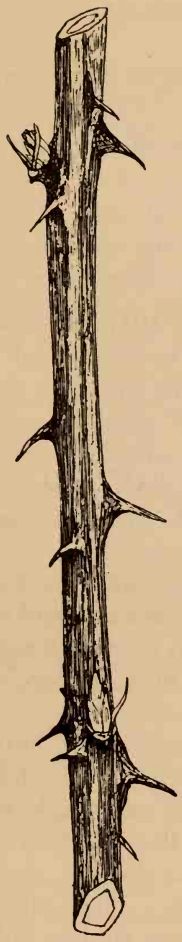


Fig. 103.

Fig. 104.

Fig. 103. Blackberry, *Rubus fruticosus*, p. 202 (D).
Fig. 104. Raspberry, *Rubus Idæus*, p. 202 (D).

Rosa spinosissima, L. Scotch Rose, Burnet Rose. A smaller and more erect bush than *R. canina*. Twigs rounded; prickles expanded at base. Lateral accessory buds may occur.

R. villosa, Downy Rose, is larger, more downy, and has no glandular hairs.

(b) **Twigs devoid of thorns or prickles, quite unarmed.**

(i) Buds few, at the tips of short, stout, hard tubercle-like dwarf-shoots, ringed with scales, and in the axils of projecting leaf-bases on the slender long twigs. Conifer.

Larix europæa, L. Larch (Fig. 105). The twigs are thin and flexuous, glabrous, green to tawny, and more or less angular and furrowed with the numerous decurrent spirally disposed leaf-bases, each of which bears a small, almost elliptical leaf-scar, with one small leaf-trace. They often carry old cones, woody, thin-scaled, and short oblong. The buds give rise to many-leafed tufts of tender green linear foliage. Young cones crimson.

Buds few, here and there on the long shoots in the axils of leaves, brownish, with resinous scales, and standing off nearly at right-angles; in section showing a small pith, and resinous irregular cortex. Twigs leather-yellow or greyish, long and pendent.

The bud consists of leaves transformed into scales, arching over the terminal dome bearing true leaves.

Each bud begins with two small scales right and left, one of which is more ciliate than the other and overlaps it at first: the next scale is opposite the axis, then follow others in a high spiral, about $\frac{5}{13}$. The outer scales are membranous, triangular-ovate and slightly pubescent, passing gradually into more delicate, broader and more rounded scales as we go inwards, and then suddenly to the green foliage leaves. As development proceeds the

delicate inner scales fall, but the outer harder ones persist. At the base of the shoot the crowded leaves appear to be in a whorl, and if it develops into a long shoot the

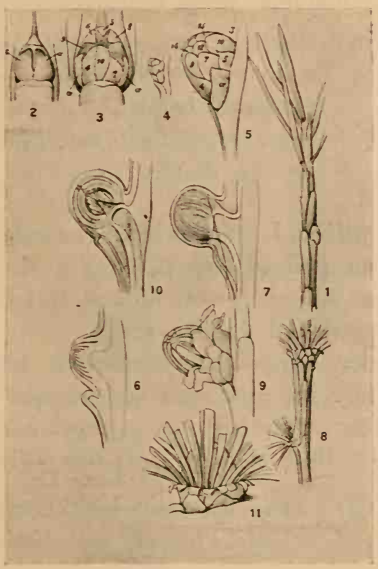


Fig. 105. Larch, *Larix europœa*. 1 part of long shoot, buds formed in axils of very few leaves; 2—5 a bud in various stages of development and dissection; 4 the bud in natural size from the side, and 5 the same magnified; 2 from the side after removing the two lateral scales; 3 front view of 5; 6 and 7 vertical sections through young and older bud, magnified; 8 dwarf-shoots, natural size; 9 and 11 the same just putting out the leaves, and 10 in vertical section, magnified, p. 204 (He).

succeeding leaves are separated by distinct internodes. But it may remain contracted as a dwarf-shoot, and repeat the process for years, not elongating more than a few millimeters each year. Or it may, at any time, suddenly grow out to a long shoot.

The Cedar is the only similar tree, but that is evergreen and has very different cones (see p. 137).

(ii) Buds not on tuberculate dwarf-shoots, or nodulose twigs bearing cones.

(*a*) *Buds minute, subtended by minute prominent bases of scale-leaves, and very numerous but many abortive; on slender twigs crowded with small imbricated grey-green scale-like leaves.*

Tamarix gallica, L. Tamarisk. The habit is somewhat Cypress-like or Ericoid (see p. 142), a resemblance enhanced by the sub-evergreen foliage, but the leaves are spirally arranged and greyish green.

The slender twigs show numerous scars of fallen branches. They are glabrous and striate and pass to darker red-brown, purplish or grey-brown curved branches, with lenticels. Buds showing very few scales.

(*β*) *Twigs not covered with densely imbricated scale-like leaves; with distinct internodes.*

* Buds on distinct stalks, lifting them out of the leaf-axils.

† Buds on pedicels as long as themselves or longer. Bud-scales 2—3 of which one nearly embraces the rest; glabrous and glaucous or viscid; leaf-scars angular shield-shaped, or rhomboid with 3—5 leaf-traces.

Alnus glutinosa, L. Alder (Figs. 106 and 34, 42). Bud and shoot triangular in section. The buds rather large, ovoid-distended, obtuse, turned slightly to one side and somewhat triangular in section (Fig. 42): there is occasionally an accessory bud which remains dormant.

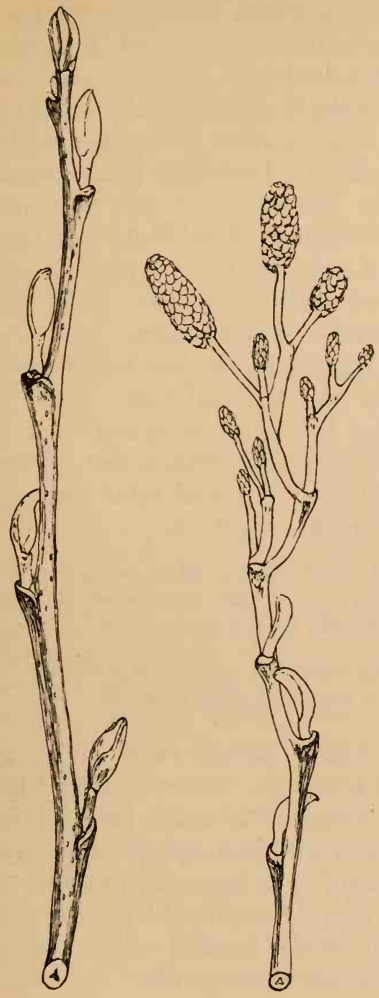


Fig. 106.

Fig. 107.

Fig. 106. Alder, *Alnus glutinosus*, p. 206 (D).
Fig. 107. Black Currant, *Ribes nigrum*, p. 208 (D).

The buds and twigs are greenish brown to red-brown with a violet shade, sometimes pronounced, the young tips with a whitish resinous bloom, all glabrous except for the waxy bloom. Lenticels distinct reddish or tawny. The violet hue of the twigs is often perceptible in alder copses, in spring, at a distance. Leaf-bases prominent and decurrent, rendering the twigs more or less triangular; leaf-scars irregularly pentagonal, shield-shaped or rhomboid, with 5 leaf-traces of which the lower 3 may be massed into one group (Fig. 59 *y*). Pith triangular. Older twigs dark olive-green to nearly black in the mass.

In the autumn the stipules of the last leaves formed remain as envelopes for the terminal bud. Each bud begins with two stipules belonging to a leaf next the axis: then follow others, each pair with a leaf between. The leaves are folded on their principal veins and curve round those enclosed (Fig. 34). Spiral $\frac{2}{5}$.

†† Buds with several spiral scales; and on stalks shorter than themselves; leaf-scars crescentic, with 3 leaf-traces.

⊙ *Buds greenish, with yellow glandular hairs on scales and twigs, aromatic.*

Ribes nigrum, L. Black Currant (Fig. 107). The leaves are plaited in bud, and the leaf-scars extend halfway round the circular twigs. Bud-scales loosely imbricated. Twigs greyish tawny with peeling papery epidermis and cortex. The buds tend to be aggregated at the ends of the twigs, which are slightly angular. The strong and rather unpleasant odour of the crushed twigs, and the papery peeling epidermis are characteristic.

⊙⊙ *Buds pale brown with a whitish violet bloom; scales closely imbricate: not aromatic.*

Ribes rubrum, L. Red Currant. Twigs pale brown, or grey, with torn papery remains of epidermis, and very similar in most respects to *R. nigrum*, but without the odour. Older branches grey. Stalks of buds often extremely short.

R. alpinum, a small rare bush, also comes here.

** Buds not stalked, but sessile.

† Twigs stout and leaf-scars large, or widely embracing; buds exposing few scales, broadly ovoid or conical, and short.

⊙ *Twigs with a white latex; pith not chambered; leaf-scars not* Y*-shaped.*

▱ *Pseudo-terminal bud ovoid-conical with a long point, green; twigs exuding white latex on cutting: pith not chambered. Leaf-scar nearly circular, with* 3 *compound leaf-traces.*

Ficus Carica, L. Fig (Figs. 33 and 59 *a*). The stout cylindrical twigs are olive-green to brownish, roughly pubescent above, with long internodes, and projecting leaf-bases bearing nearly circular large leaf-scars, from the top of which the narrow linear scars of the stipules extend obliquely round the twig and meet behind. The large glabrous green conical pseudo-terminal bud shows two scales, stipules, one embracing the other (Fig. 33). Lateral buds very small, sometimes in pairs side by side, blunt-conical and depressed in the axil, or even somewhat axillary. Pith white, round and large.

The leaf-buds are enveloped in two stipules, twisted into a conical cap-like and pointed cover, greenish or somewhat olive, and with traces of cilia. The flower-buds expose several scales and are blunter and larger than the

ordinary lateral buds. Lenticels not numerous and usually confined to near the nodes, which are solid.

The stipules of the last leaf formed in autumn persist after its fall as the cover to the terminal bud. On removing this we find the next leaf rolled over its stipules. On removing this leaf and its first stipule, the second stipule is seen nearly surrounding the rest of the bud, and so on, in a spiral of $\frac{2}{5}$.

Each lateral bud shows an outer scale enveloping all inside: inside this is another distichous with it: within this another, and so on till about the fifth. These scales are conjoined stipules. At the 5th or 6th scale the stipules are becoming free, and show the leaves now passing into the spiral arrangement.

Morus, the Mulberry, has also large caducous stipules protecting the bud (Fig. 22), and a white latex; but the buds are ovate, clothed with scales, and the twigs much thinner.

The terminal bud is rarely developed. The bud starts with about 6—8 scales consisting of fused pairs of stipules, the inner of which may be partially separated and show leaf-incepts between. Then follow leaves with their stipules, the former becoming larger in proportion to the latter as we proceed with the dissection. The stipules are so folded that the one next the parent shoot overlaps the second one of the same leaf.

▱▱ *Buds not long-pointed; leaf-scar not circular, and with more than* 3 *leaf-traces.*

§ *Buds naked, very short, blunt ovoid-conic, densely hairy, as are also the twigs, and nearly surrounded by the incompletely ring-shaped, or horse-shoe-shaped leaf-scar, which has numerous leaf-traces.*

Rhus typhina. Sumach. The buds are really naked, on somewhat prominent oblique leaf-bases, and the leaf-traces grouped (Fig. 59 *i*). Pith large and brownish. Twigs stout, rounded, olive-brown and densely velvety-haired, passing to smooth with prominent lenticels. The terminal—or pseudo-terminal—bud not larger than the laterals: exposing about 2 leaves.

§§ *Buds almost dome-shaped, exposing about* 3 *scales, slightly pubescent; leaf-scars shield-shaped, with* 7 *curved leaf-traces equally distributed; twigs smooth, buds, leaf-bases hardly protruding.*

Ailanthus glandulosa. Tree of Heaven (Fig. 59 *c*). Buds small and all equal in size, red-brown with a grey tomentum. Pith large, brown-orange. Twigs practically glabrous, shining yellowish to reddish brown or olive, with pale scattered and elongated lenticels.

The terminal bud is usually aborted. The bud begins with two much reduced scales, right and left, followed by a third scale facing the axis, then passing on spirally. The third onwards may show rudiments of the lamina at the apex, and the innermost leaves have minute stipules.

⊙⊙ *Twigs devoid of latex, but with chambered pith; leaf-scars broad* Y*-shaped, with* 3 *compound leaf-traces, on prominent leaf-bases. Buds fat-ovoid, the terminal—or pseudo-terminal—the larger.*

Juglans regia, L. Walnut (Figs. 108 and 59 *d*). The true terminal bud is usually aborted, its scar subtending the leaf-opposed side of the large pseudo-terminal bud. Twigs glabrous, shining, with numerous longish lenticels. Pith broad and angular, and broken up into close-set

diaphragms with hollow chambers between, at once evident on cutting (Fig. 108). The twigs are not flattened at the apex.

The stout glabrous cylindrical twigs are greenish to ash-grey and have resemblances to those of the Ash —e.g. the prominent leaf-bases and black lateral buds; but the terminal or pseudo-terminal bud is grey tomentose and the laterals glabrous, the leaf-scars broadly Y-shaped, or angular heart-shaped, and very different, and not opposite. The lateral buds are often extra-axillary or accompanied by superposed accessory buds: two opposite bud-scales almost entirely conceal the rest, which are in three ranks.

Fig. 108. Walnut, *Juglans regia*, p. 211 (D).

The terminal and flowering buds may expose more than 3 scales, and be dark or nearly black in colour, somewhat shining, though microscopically hairy. Branches olive-grey to brownish, with evident lenticels.

The bud-scales are leaf-bases (Figs. 48 *c* and 49 *d*). The young bud has a closed enveloping scale with a

notch at the top, and is covered with fine caducous hairs. As the bud increases this split-scale is pushed to one side. The next inner scale is anterior, and is followed by about 6—9 others before the laminæ are distinguishable. The arrangement is spiral, the leaf-segments obliquely involute.

†† Twigs not remarkably thick and often slim; never with latex; leaf-scars small or very thin; terminal bud usually present.

⊙ *Buds conical and showing one cap-like scale almost enclosing a second scale, surrounded at its base by the narrow ring-like scar of the fallen leaf; bud-scales brown; twigs zig-zag, olive-green or grey, pubescent at the tips.*

Platanus occidentalis, L. Plane (Figs. 109 and 19, 20, 37). The buds are equal in size, and completely hidden in the base of the leaves in summer, the ring-like insertion of which is nearly but not quite closed (Figs. 19 and 20). The leaf-scar is sinuous on its outer margin, and has the numerous leaf-traces grouped in threes and fives (Fig. 59*k*). Bud-scales often more or less twisted, but not drawn to a long point, striate, more or less silky pubescent, and pale brown or olive. Twigs rounded, slightly rilled, and with traces of tomentum at the nodes; olive-green, with numerous tawny minute lenticels, passing to olive-grey smooth branches which soon show the characteristic casting of the periderm in thin plates.

The development of the bud in a hollow at the base of the petiole, and opening by a minute aperture at the upper side, is shown in Fig. 20. The somewhat leathery outer bud-scales are closed stipules, fitting cap-like one over the other, and getting more delicate in texture as we proceed inwards. Then come the small revolute leaves,

each between two of the caps, and arranged in a distichous manner (see Fig. 37).

P. orientalis cannot be distinguished by the buds and twigs.

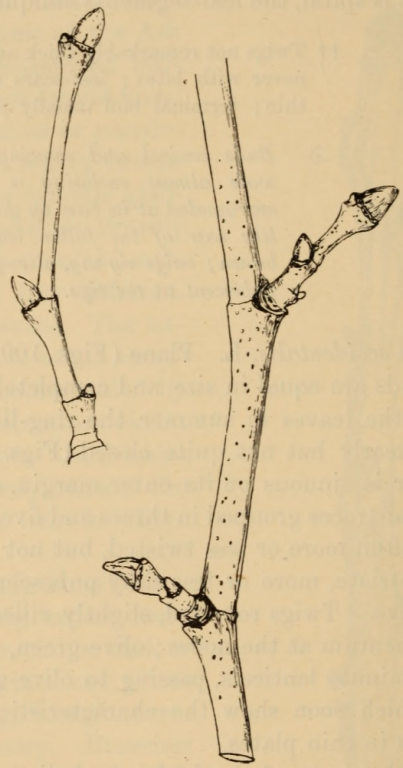


Fig. 109. Plane, *Platanus occidentalis*, p. 213 (D).

⊙⊙ *Leaf-scars not annular and not embracing the buds.*

▱ *Buds naked, greyish, hairy, the terminal larger but all small; twigs thin, pubescent at tips.*

Rhamnus Frangula, L. Alder Buckthorn (Fig. 110). There may be one or two minute stipular scales beneath the exposed young foliar leaves composing the bud, but they do not enclose them. Twigs slightly angular above,

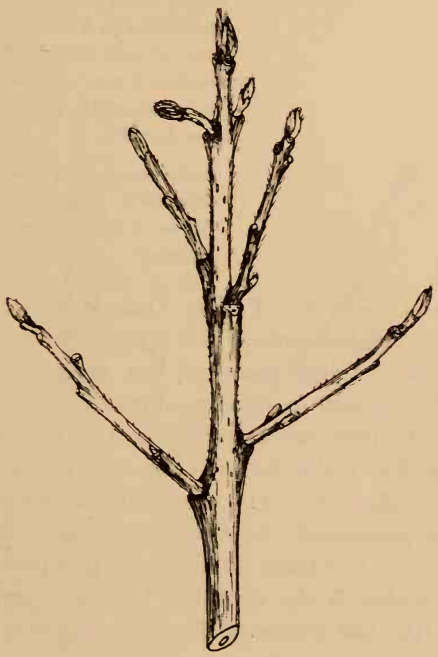


Fig. 110. Alder Buckthorn, *Rhamnus Frangula* (D).

violet-brown, slender, with elongated obvious grey lenticels, passing to grey or grey-brown. The uppermost lateral bud often close beneath the terminal one. Dwarf-shoots numerous and nodulose with leaf-scars. Leaf-scar small, semi-lunate, with three leaf-traces. Pith pale, small, rounded, and dotted with pores.

▱▱ *Buds enclosed in one or more true scales, not naked.*

§ *Bud-scales several or many, spirally imbricate.*

‡ *Buds aggregated at the tips of the twigs, ovoid; bud-scales numerous, imbricated in 5 ranks; branches with scars of cast twigs. Pith 5-ranged. Leaf-scars more or less semi-lunate to crescentic, small, with numerous leaf-trace bundles.*

÷ *Buds hairy, and surrounded with persistent filamentous stipules of fallen leaves; apex of twigs grey velvety.*

Quercus Cerris, L. Turkey Oak, Mossy-cupped Oak. The grey fimbriated buds at the apex of the twig are very characteristic. Twigs more or less angular, passing to smooth olive-green or tawny; branches grey to slate-coloured, with prominent leaf-bases and lenticels. Buds with rather few scales for an Oak, and blunt; the scales ciliate and pubescent. On the dwarf-shoots the stipules may be less persistent. Leaf-scars small, semi-lunate, with about 7 minute leaf-trace bundles, not grouped (Fig. 59 *l*). The outer scales of the terminal bud are formed by the stipules of the last leaves of the preceding season.

÷÷ *Buds tawny, glabrous and glistening, blunt-ovoid, with numerous scales, and without the sheath of filamentous stipules.*

Q. Robur, L. Oak (Figs. 111 and 30). Shoots fairly stout, and leaf-scars small, triangular-lunate, or nearly elliptical, with numerous grouped leaf-traces, on projecting leaf-bases (Fig. 59 *n*); twigs silvery or greenish grey

passing to tawny, glabrous, and somewhat rigid. Pith pentangular-stellate. Buds crowded, rather large, and sometimes slightly displaced from the axils. Lenticels scattered. Bud-scales pale tawny ciliate; twigs olive to

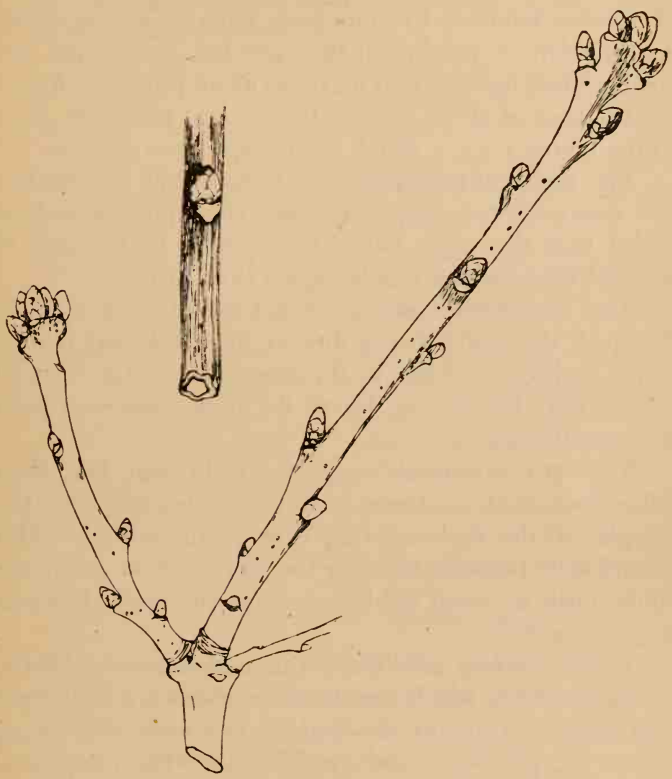


Fig. 111. Oak, *Quercus Robur*, var. *pedunculata*, p. 216 (D).

red-brown and more or less angular, but often silver-grey. Dwarf-shoots numerous and very nodose.

At the end of the summer the last leaf-structures to

be formed are stipules, and these persistent stipules are the outermost bud-scales. The uppermost complete leaves are crowded, and each forms a bud in its axil, so that the buds are aggregated at the ends of the shoots.

Each bud begins with two scales—fused stipules devoid of leaves—followed by numerous stipular scales, which are broader, of parchment-like texture and ciliate, becoming more delicate and narrower as we proceed. About 8—12 pairs of these have to be removed before we come to the leaves, each of which lies between two stipules.

The first leaf-rudiments are minute and lie flat, but the more normal inner ones are conduplicate, and so folded that the edges follow the spiral. In the core of the bud they become smaller again (Fig. 30).

The completed bud is ovoid-conoid and slightly 5-angled, the angles being due to the thickened middle of the scales,—i.e. what would correspond to the midribs if they were leaves: the leaves lie in the flattened parts between the angles.

The two outermost scales lie right and left, then follow two on the anterior next the subtending leaf, the margin of the first covering that of the second. This second scale (stipule) overlaps the next, and so on in the spiral, until we reach the leaves, when the spiral becomes more pronounced.

In the variety *sessiliflora* the bud-scales are ciliate, giving the buds, which may be more slender, a dull matt appearance; while in the variety *pubescens* the young shoots are pubescent and greyish, somewhat resembling *Q. Cerris.*

Other Oaks to be noted are *Q. rubra* and *Q. coccinea.* In *Q. coccinea* the bud-scales are glabrous but ciliate, and the leaf-scar like that of *Q. Cerris*; in *Q. rubra* the scales are slightly pubescent, and the leaf-scar has groups of

bundles. For evergreen Oaks see pp. 148 and 149: it may be mentioned that the dead leaves of the ordinary Oak may remain on through the winter in certain circumstances.

[*Prunus Avium* has a decided tendency to aggregation of the buds on the dwarf-shoots.]

ǂǂ *Buds not specially aggregated at the tips of the twigs, or if so only on the dwarf-shoots. Scales not in* 5 *ranks.*

÷ *Buds viscid, more or less acute and on prominent leaf-bases; twigs and buds glabrous or nearly so.*

8 *Buds slender, with sharp conical points, the laterals appressed more or less, not green, the two lowermost bud-scales lateral to the leaf-scar or partially fused; pith angular or* 5*-rayed stellate; twigs slender and inclined to be angular above, and to light colours—e.g. yellow-tawny or grey-brown.*

△ *Buds long ovoid-acute or nearly acuminate, hardly appressed, tips often incurved, shining pale brown; twigs the same colour, rounded, and glabrous.*

Populus tremula, L. Aspen (Fig. 112). Buds small, brown, and somewhat Elm-like, but the few scales, about 4, are not distichous, though they are ciliate and have traces of pubescence. The lateral buds are erect, but hardly appressed. Dwarf-shoots thin, very knotty, owing to the projecting leaf-bases, and more or less shortly pubescent. Twigs polished, rounded, yellowish brown or tawny, passing to olive-grey or slate-coloured, with scattered lenticels. Leaf-scar semi-lunate with 3 small

leaf-traces, on somewhat prominent leaf-bases. Flower-buds larger, fatter and more ovoid.

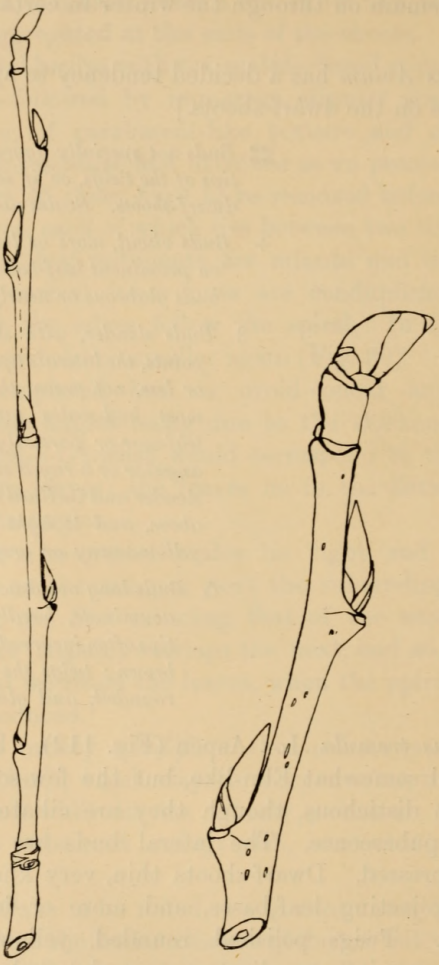


Fig. 112. Aspen, *Populus tremula*. Shoot to right enlarged, p. 219 (D).

The buds are sometimes slightly triangular in section, polished brown, resinous; twigs long and slender, greyish green to tawny or reddish brown.

△ △ *Buds not ovoid, more conical and taper-pointed, appressed or directed outwards, not incurved, twigs slightly angular at the tips.*

P. nigra, L. Black Poplar (Fig. 113). The flower-buds are larger and tend to be recurved at the apex. All are conical, or cylindroid-conic with tapering sharp points, and often very viscid. The terminal bud may be much the larger, and expose 7—8 or more scales, the laterals sometimes very small. Lenticels scattered. Leaf-scars as in *P. tremula,* or narrower and inclined to crescentic, on rather prominent leaf-bases.

Twigs shining yellow or yellow-tawny and glabrous, passing to olive-grey or darker grey, usually round below and devoid of corky ridges, but slightly angular above, or striate. Terminal and flowering buds much larger than the rest, especially on the dwarf-shoots. The variety *pyramidalis,* Lombardy Poplar, Pyramidal Poplar, differs in nothing except the more vertical direction of the lateral twigs. The buds are usually small and appressed.

The bud-scales are stipules, but broader, more shortly pointed and more leathery than the ordinary stipules. The outermost pairs have no traces of leaves between, but as we go in—at about the 7th to 9th pair in the large terminal buds—they become narrower and more delicate and each pair has its corresponding, involute, leaf (Fig. 27).

Each lateral bud has one anterior scale surrounding the bud, but open on the posterior side. This is followed

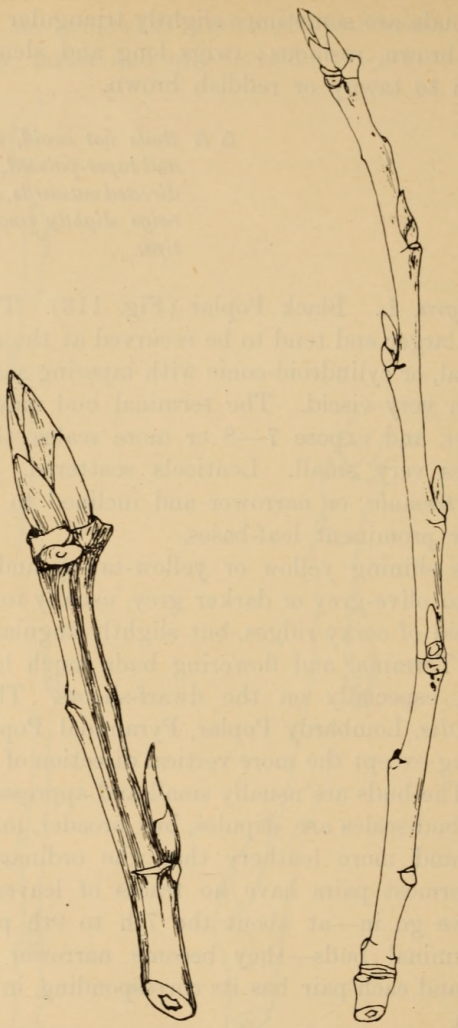


Fig. 113. Black Poplar, *Populus nigra*. Shoot to the left enlarged, p. 222 (D).

by another, dorsal, and open to the anterior. The third scale in is antero-lateral, and only extends partially round the bud (Fig. 17). Then follow the involute leaves and their stipules in spiral succession.

In some Poplars there are several distichous scales before the spiral begins.

In *P. Canadensis* the buds are larger and more angular, pyramidal-pointed and directed outwards; twigs more angular. It is not easily distinguished from *P. nigra*, but the buds are larger, more acutely conical-triangular and directed obliquely upwards and outwards, and the greater angularity of the twigs may be accentuated by corky ridges. The branches also are usually more spreading.

8 8 *Terminal buds the larger, fat, ovoid, with blunt points; lateral buds not appressed; a single lowermost bud-scale anterior over the leaf-scar; twigs rather stout and round, inclined to dark colours —e.g. purple-brown, &c.; pith rounded; leaf-scars narrow crescentic with* 3—5 *leaf-trace bundles. Bud-scales green or olive, or tinged red, shining and viscid.*

Pyrus Sorbus, L. Sorb (Fig. 59 *g*). Twigs olive-green to pale brown or greyish, glistening above, glabrous, or with traces of hairs towards the tip, fairly stout and round; bud-scales olive-green with very narrow brown border. Dwarf-shoots stout and much ringed. Buds erect but not appressed, the terminal one larger, leaf-bases slightly prominent; lenticels numerous and small; leaf-scars crescentic and with 5 leaf-trace bundles.

Very few of our trees have viscid buds. *Æsculus* has been dealt with (p. 150); others are, *Alnus*, *Betula* (var. *glutinosa*), *Azalea*, *Rhododendron*.

Pyrus Aria also tends to be slightly viscid at the tips of the buds, which are stouter and more obtuse, with brown borders and a few hairs on the margin of the green scales (see p. 236).

÷÷ *Buds not viscid, or at least not markedly or persistently so, and not conical and long-pointed. Leaf-scars small, semi-lunate or crescentic, with* 3—5 *leaf-trace bundles.*

8 *Buds hairy with obvious silky pubescence or cottony down.*

△ *Buds and shoots silky pubescent with white hairs, not cottony or tomentose; older twigs glabrous.*

♂ *Buds and greenish shoots white with silky appressed hairs; older twigs grey-green to olive; lateral buds small, ovoid-flattened, on prominent leaf-bases on which the minute stipules remain. Leaf-scar semi-lunate with* 3 *leaf-trace bundles.*

Cytisus Laburnum, L. Laburnum. Bud-scales few, about 3, rather loose; terminal bud surrounded by several leaf-bases bearing stipules; twigs olive-grey as the papery epidermis sloughs off, the older smooth olive, with small round lenticels. Most of the lateral buds are aborted or give rise to short densely ringed dwarf-shoots, whence the sparse branching; pith round. Terminal bud hardly larger than the laterals; leaf-scar semi-lunate, with 3 approximated leaf-traces. Twigs slightly angular or striate, becoming smooth and grey-green with minute lenticels.

dd Stipules not persistent on the leaf-bases; shoots and buds not silky white-greenish, but more or less purple-brown.

z *Young shoots pubescent, twigs reddish brown to maroon-greyish, glabrous; buds, especially the terminal one, large, black and grey,* 10—15 *mm. long; the shining violet-black scales covered and fringed with long white silky hairs; the outermost scale anterior over the leaf-scar. Leaf-scar crescentic, narrow, with* 5 *leaf-trace bundles.*

Pyrus Aucuparia, Gaertn. Rowan, or Mountain Ash (Figs. 114 and 115). Buds large, shining, and with a slight velvety pubescence, and white cilia to the scales, chiefly confined to the inner bud-scales. Terminal bud ovoid-conical; lateral ones smaller, somewhat flattened and appressed. Twigs rather robust, shining greyish to red-brown or deep brown, with evident but not numerous yellowish lenticels, passing to deep grey or slate-coloured. Outer bud-scales glistening and almost black, inner velvety brown. Cortex with an unpleasant odour when crushed. Dwarf-shoots prominent and densely ringed. Leaf-scars crescentic with 5 leaf-trace bundles, on rather prominent leaf-bases. Pith small and round.

zz *Buds not black and grey, silky, or large; but more or less velvety or cottony, as are the young shoots.*

> *The two outermost lower bud-scales flanking the leaf-*

scar; twigs cottony; pith angular. Leaf-scar semi-lunate with 3 *leaf-traces.*

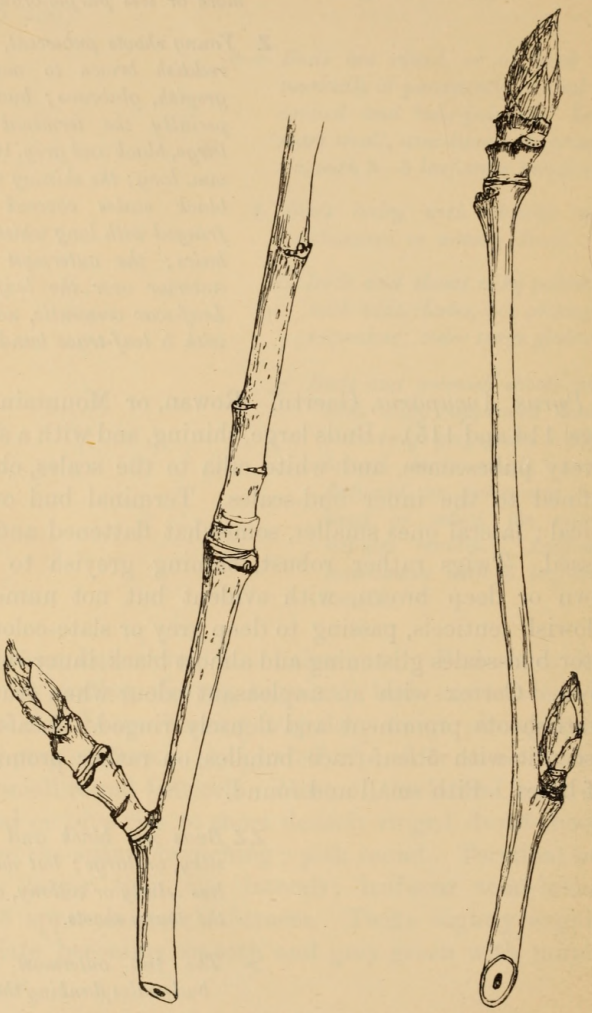


Fig. 114. Rowan, *Pyrus Aucuparia*, p. 225 (D).

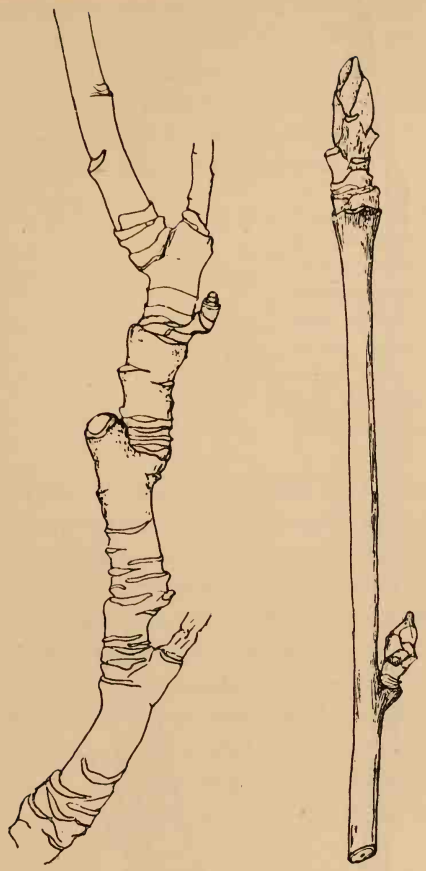


Fig. 115. Rowan, *Pyrus Aucuparia*, p. 225 (D).

Populus alba, L. White Poplar, or Abele (Fig. 116). Twigs with a loose cottony tomentum, easily rubbed off. Buds like those of *Populus tremula* (p. 219) but not viscid;

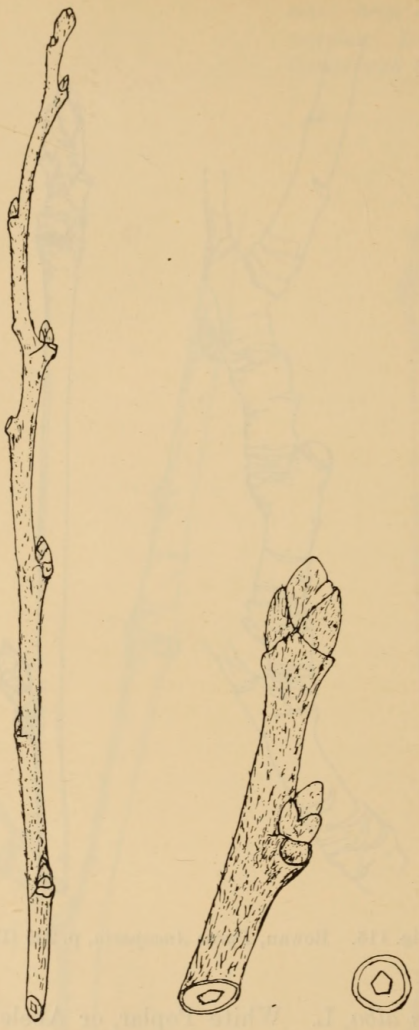


Fig. 116. White Poplar, *Populus alba*. Figure to the right enlarged, p. 227 (D).

bud-scales ciliate and usually tomentose. Buds small, narrow-ovoid, acute, not appressed, small, with few scales covered with a loose cottony white tomentum as are also the shoots, and this persists on the olive-brown or grey twigs, giving them a greenish grey hue. Leaf-bases hardly prominent; leaf-scars more or less semi-lunate, with 3 leaf-traces, one of which may be compound.

>> *Buds small, broad, and depressed hemispheric-conoid, and somewhat triangular or flattened in section; they and the twigs reddish to brown, and pubescent-velvety: pith round. Leaf-scar crescentic with 3 leaf-trace bundles.*

Pyrus Malus, L. Apple (Fig. 117). The terminal bud is somewhat larger and inclined to ovoid, especially on the dwarf-shoots. Twigs becoming smooth, red-brown, with traces of tomentum. Dwarf-shoots common, stout, irregularly curved and very rough with the crowded crescentic leaf-scars, and sometimes almost thorny. Bud-scales acute, red-brown, but whitish with hairs. Twigs round, shining, with evident but small and scattered lenticels. Leaf-scar crescentic. The bud-scales are stipules. The young leaves in the bud are spirally arranged and involute, with the stipules laid flat on their dorsal flanks (Fig. 40).

Cydonia vulgaris would also come here, but the tomentum on buds and twigs is reddish. The leaves are not inrolled: otherwise as in Apple.

In *Cotoneaster* the deep red-brown twigs are pubescent

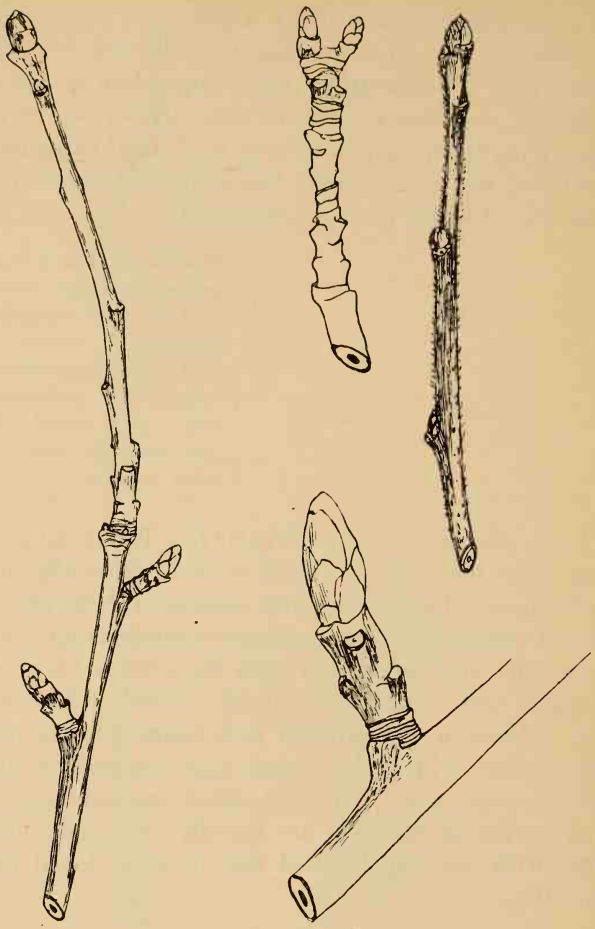


Fig. 117. Apple, *Pyrus Malus*. To the right below a dwarf-shoot enlarged, p. 229 (D).

at the tips, and the buds expose the silky hairs of the enclosed leaves (Fig. 118).

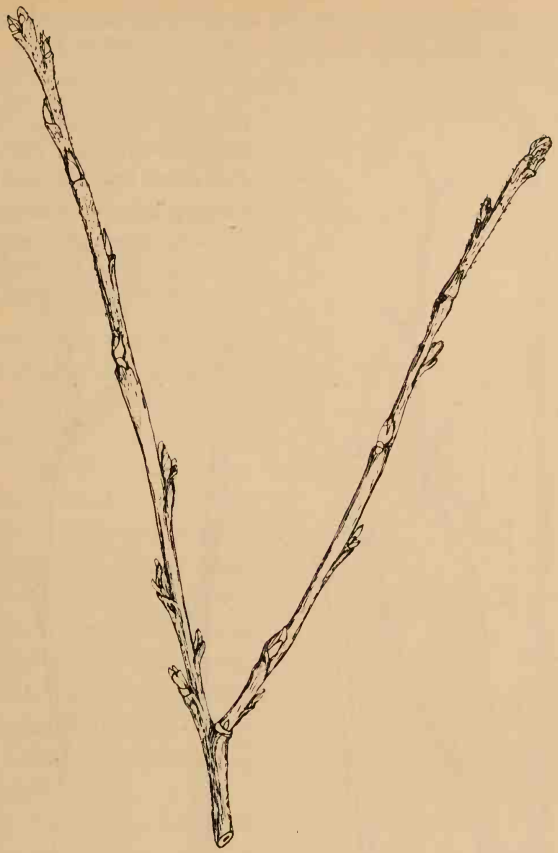


Fig. 118. Cotoneaster, *Cotoneaster vulgaris*, p. 229 (D).

Prunus insititia has pubescent twigs and buds (see p. 243). See also *Betula pubescens* (p. 234).

8 8 *Buds and twigs glabrous, or at most with traces of pubescence inappreciable to the touch or naked eye.*

△ *Buds small, on long and very slender whip-like twigs rough with verrucose glands or lenticels, and resinous-odorous or waxy. Leaf-scar small, nearly elliptical, with 3 minute leaf-traces. Pith small, irregular and green.*

Twigs more or less pendent, with minute rough waxy glands on them and on the small buds, or with distinct lenticels.

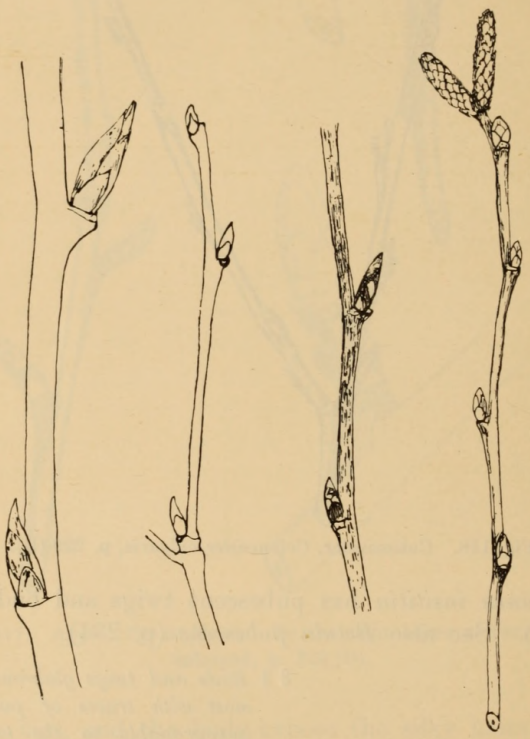


Fig. 119. Birch, *Betula alba*. The left-hand figure enlarged, p. 233 (D).

Betula alba, L. Birch (Figs. 119 and 120). Buds short-ovoid, pointed, glabrous, and somewhat appressed, with a tendency to be distichous (see p. 188). Twigs greyish brown when the waxy scales are abundant, but varieties are met with in which they are smooth glistening brown—in var. *pubescens* even pubescent—as the older twigs generally are except for the lenticels. Dwarf-shoots not common, and must be distinguished from stalked buds, which they resemble. An accessory bud sometimes occurs. Bud-scales ciliate, red-brown or flecked with green, passing to smooth rich brown. Leaf-scars very small, more or less elliptical, with 3 minute leaf-traces, on scarcely prominent leaf-bases (Fig. 59 *v*). Buds often oblique to the scar.

The true terminal bud is usually aborted and a pseudo-terminal axillary bud replaces it, except on the dwarf-shoots which often end in a bud. The bud-scales are stipular, and the leaves lay their plicate surfaces one over the other.

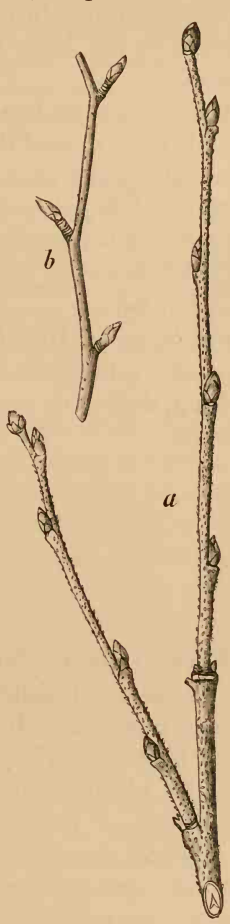


Fig. 120. Birch, *Betula alba*, v. *verrucossa*. *a* long shoot, *b* dwarf-shoots (Sc).

The first two scales are the stipules of the last season's leaf left behind; then follow about two pairs devoid of leaf-rudiment, passing gradually into leaves and stipules in a slight spiral. In buds of the same side the first scale is turned to the same side, the second scale distichously opposite.

There are considerable variations in detail as regards the buds and twigs of this wide-spread species. The buds of the sub-species or variety *B. glutinosa,* Fries, are viscid, and those of *B. pubescens* more or less hairy, and the twigs vary much in being pendent or erect, and rough or smooth. The older branches of all soon show the white periderm peeling in flakes.

Betula nana, Dwarf Birch, has stiff, erect, very thin twigs and minute buds, essentially like *B. alba,* but, if anything, darker in colour, and therefore nearly black in the mass.

∂∂ Buds small, rounded-ovoid, blunt. Twigs erect, much branched, violet- or red-brown, with prominent leaf-bases and lenticels. Leaf-scar more or less semi-lunate with 3 *leaf-traces.*

Myrica Gale, L. Sweet Gale. The brown bud-scales have a pale whitish margin, and the whole plant a resinous fragrance. Buds with waxy excretion, reddish. Twigs brittle varying to yellowish, and with golden scale-like glands scattered here and there, passing to deep brown or nearly black. The scale-glands towards the tips of the twigs may produce an appearance of bronzing, approaching that of *Hippophaë* (p. 191), but there are no traces of thorns. Leaf-scars semi-lunate or nearly triangular, with three leaf-trace bundles; on prominent leaf-bases.

△△ *Buds usually larger; twigs much stouter, rigid, not verrucose or resinous-fragrant.*

♂ *Buds green or olive, the terminal the larger, the few scales more or less green and herbaceous, with brown margins. Leaf-scars with* 3 *leaf-trace bundles.*

Z *Buds sub-globose, rather large,* 6 *mm. or more in diameter; bud-scales green, herbaceous, with narrow brown margin; twigs polished brown with prominent lenticels. Leaf-scar semi-lunate.*

Pyrus torminalis, L., Ehr. Service Tree (Fig. 121). Buds globoid, obtuse, shining and nearly glabrous, not appressed, and with no resinous secretion or marked odour. The bud-scales broad and short, with scalloped or bifid tips. Leaves conduplicate in bud. Twigs slightly angular, polished, olive or red-brown, passing to purplish brown, or grey. Lenticels numerous, pale and small. Leaf-scar semi-lunate, with three leaf-trace bundles.

ZZ *Buds green or olive, fat, ovoid,* 10—12 *mm. in length, hardly acute, with several leaf-bases surrounding the terminal one; twigs stiff and fairly stout, not malodorous when bruised. Leaf-scar crescentic.*

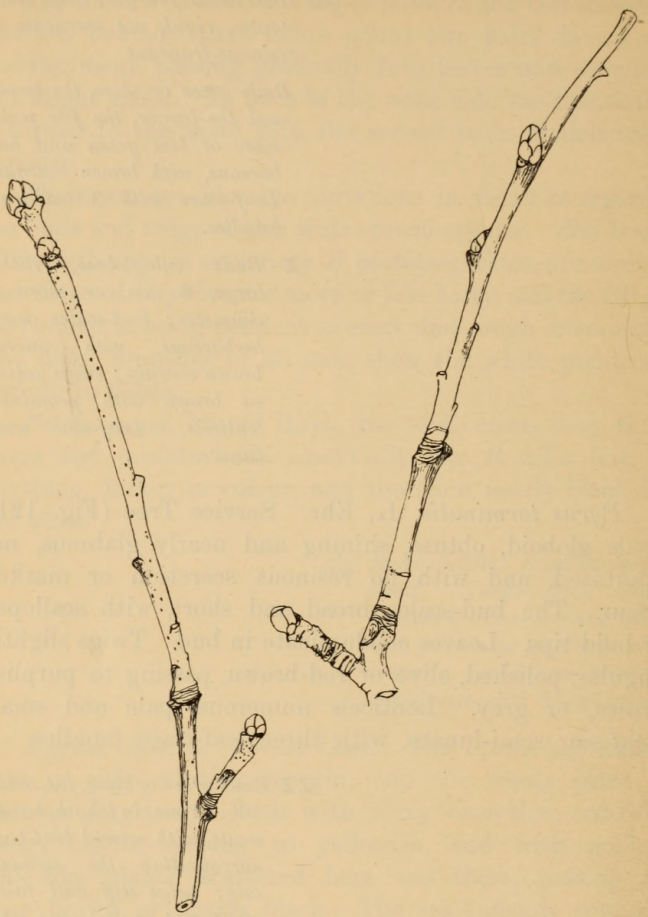


Fig. 121. Service Tree, *Pyrus torminalis*, p. 235 (D).

Pyrus Aria, L. White Beam (Figs. 122 and 123). Buds more or less angular owing to the keels of the scales; scales green with brown ciliate margins. Leaf-

scars narrow-crescentic with three leaf-trace bundles,

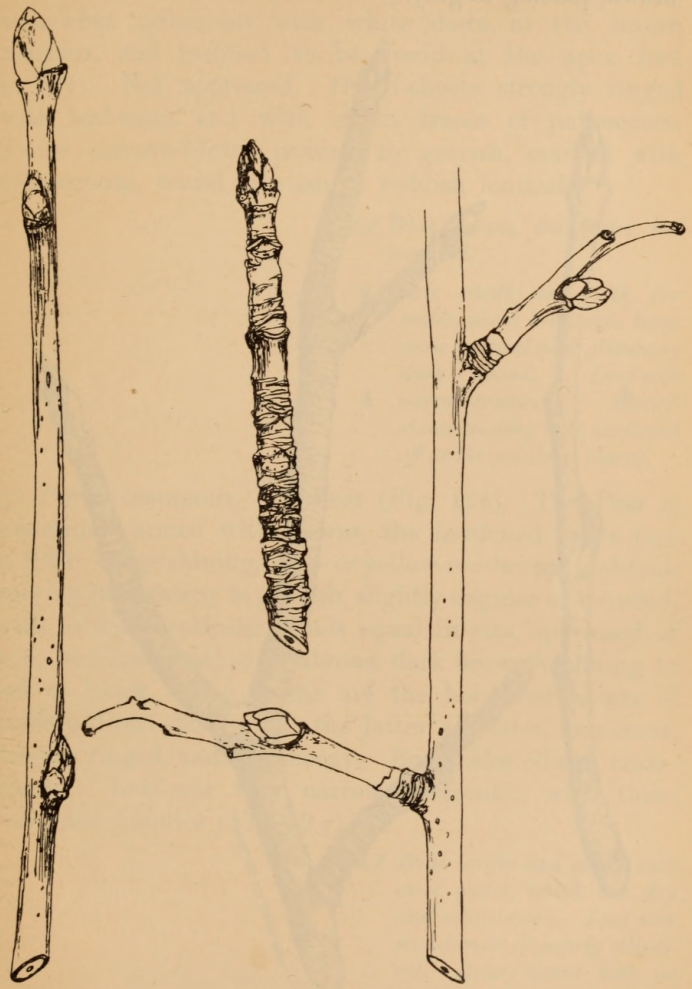


Fig. 122. White Beam, *Pyrus Aria*, p. 236 (D).

on prominent leaf-bases. Twigs round, shining, red-olive-brown, passing to grey.

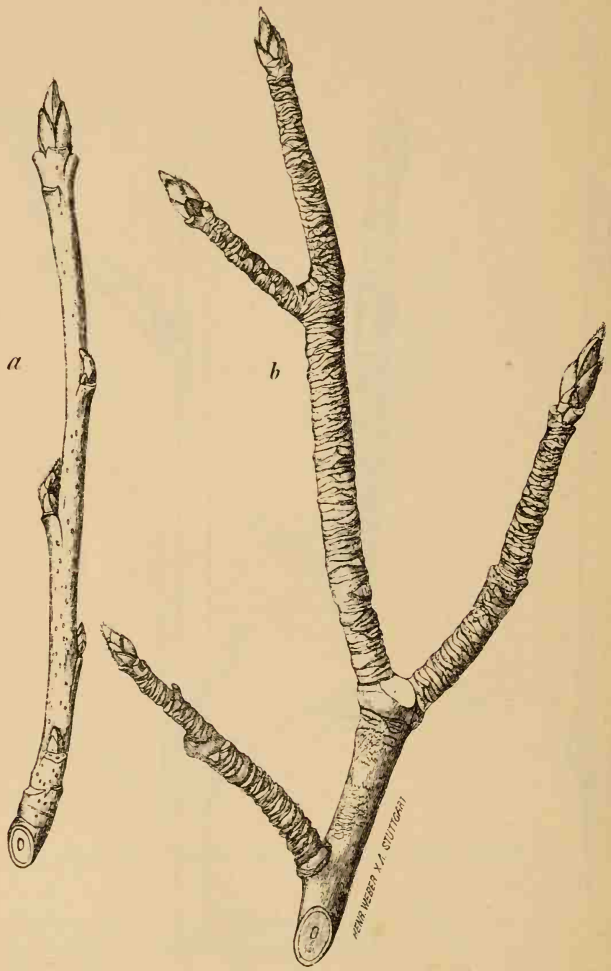


Fig. 123. White Beam, *Pyrus Aria*. *a* long shoot, *b* dwarf-shoots (Sc).

Buds ovoid, conical-pointed, the terminal larger, the lateral ones unequal; scales nearly herbaceous and keeled, somewhat pubescent with white down at the brown margins, and inclined to be viscid at the apex (see p. 224). Not appressed. Dwarf-shoots strongly ringed with leaf-scars, and with slight traces of pubescence. Twigs maroon-brown passing to greyish, marked with conspicuous, round, whitish or reddish lenticels.

ϑϑ *Buds brown, the scales not bordered.*

Z *Buds small and with few scales, about* 5—6 *mm. long, conic pointed and glistening dark brown. Leaf-scar narrow-crescentic. Dwarf-shoots tending to be hardened off at the points as thorns.*

Pyrus communis, L. Pear (Fig. 124). The Pear is sometimes armed with thorns, the hardened spurs (see p. 196). Twigs shining, olive- or yellow-red-brown, glabrous, varying from tawny to greyish, slightly angular or rounded, with evident lenticels. Buds equal in size, appressed or not; bud-scales acute; glabrous, dark brown inclining to red or black. The thorns are the hardened points of axillary dwarf-shoots; but the latter are often numerous, densely ringed, and not thorny. Bud-scales ciliate, emarginate. Leaf-scar very narrow, crescentic, with three leaf-trace bundles (Fig. 59 *g*).

ZZ *Buds larger and ovoid, with more scales, which are dry and matt-brown. Leaf-scar semi-lunate or nearly elliptical. Dwarf-shoots with no tendency to form thorns, and usually with aggregated buds.*

> *Twigs stiff and erect, with long ovoid-conic and sharp-*

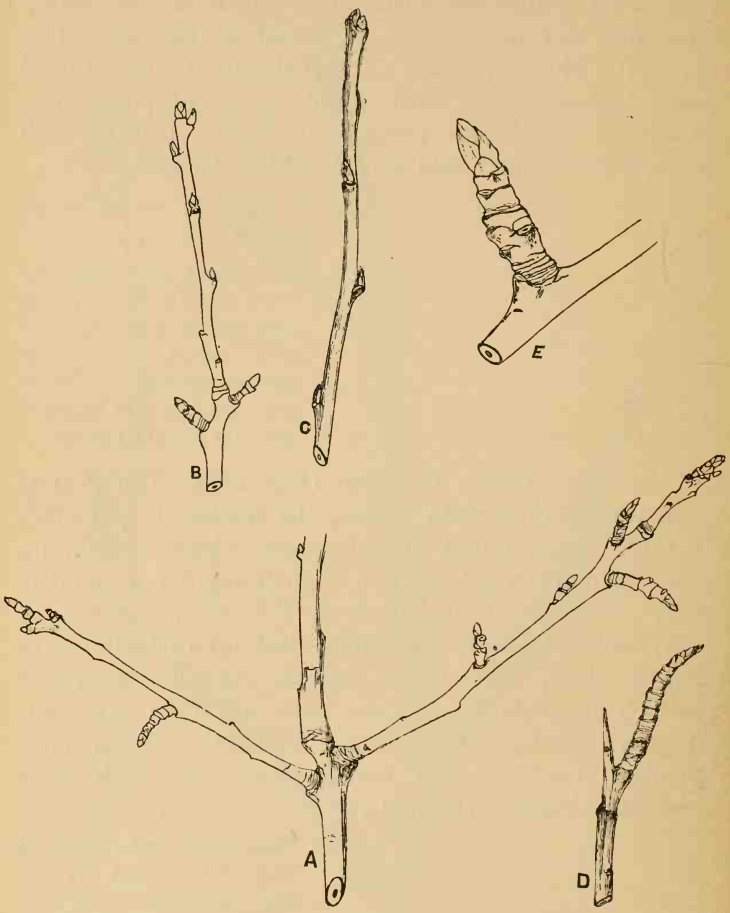


Fig. 124. Pear, *Pyrus communis*. *A* and *B* showing ordinary spurs; *C* a long shoot; *D* showing thorn; *E* a spur slightly enlarged, p. 239 (D).

ly pointed buds, and very distinct dry brown scales; older twigs with transversely

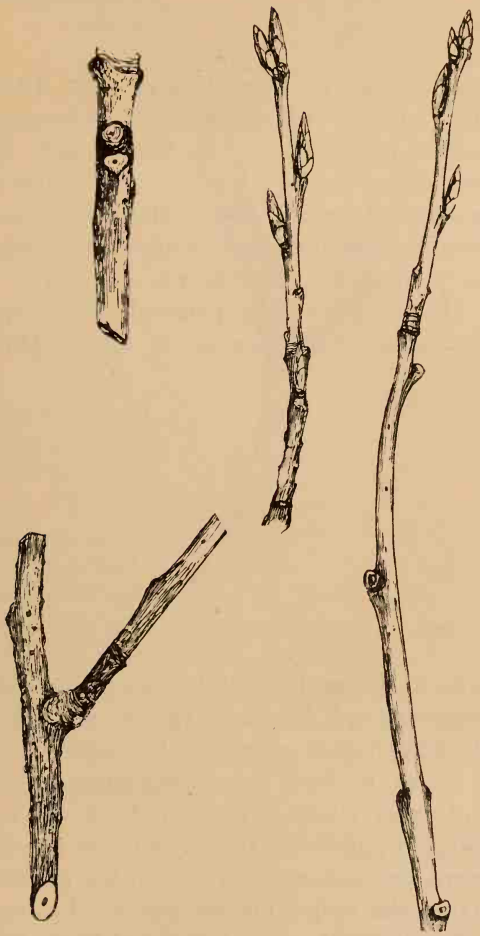


Fig. 125. Bird Cherry, *Prunus Padus*. The long shoot to the right continues that to the left below, p. 242 (D).

elongated lenticels; cortex yellowish and stinking when bruised. Leaf-scar rounded, nearly oval, with 3 *leaf-trace bundles.*

Prunus Padus, L. Bird Cherry (Fig. 125). Twigs practically glabrous, or with traces of pubescence at tip. Pith rounded, pale. The rather large, nearly erect, long conic buds are about equal in size, and have numerous brown scales with a paler margin, slight keel, and pointed tips; lateral buds appressed or incurved at the tips. Twigs olive- to reddish or violet-brown to grey. Lenticels evident. Lowest bud-scales polished brown, upper paler and with traces of pubescence or matt. Dwarf-shoots slender.

>> *Buds more or less ovoid-acute, longer than broad; bud-scales closely spiral, imbricated.*

⅗ *Leaves convolute in bud; buds small,* 2—3 *cm. long; leaf-bases prominent, leaf-scar small and rounded.*

Prunus domestica, L. Wild Plum (Fig. 126). Young shoots glabrous and devoid of spines; twigs greenish to brownish, smooth, with numerous lenticels. Buds conoid, pointed, brown to dark grey, sometimes with accessory buds; bud-scales ciliate. Twigs red, or red and green, passing to grey; glabrous, slightly angular above. Dwarf-shoots small and numerous, and, with the prominent leaf-bases, giving the twig a nodose aspect. Leaf-scars small and nearly elliptical, with three leaf-trace bundles, on prominent leaf-bases.

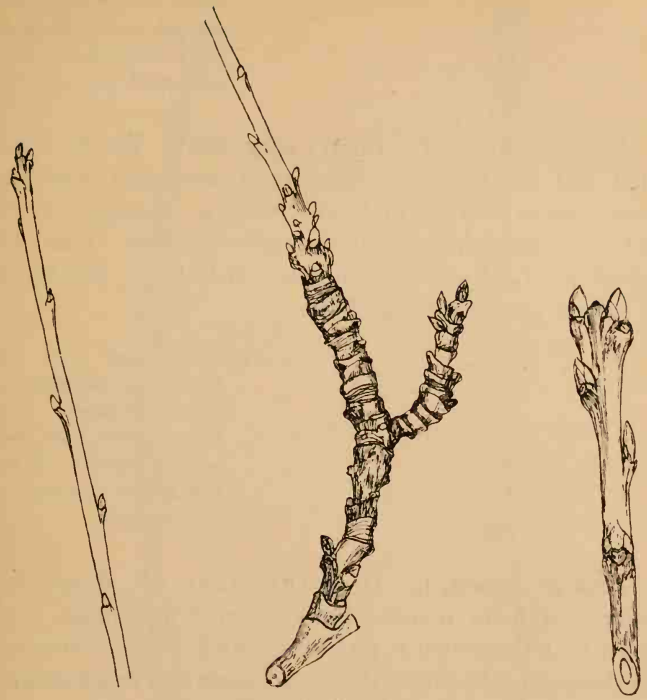


Fig. 126. Wild Plum, *Prunus domestica*, p. 242 (D).

P. insititia, the Bullace (Fig. 127), is a variety allied with the foregoing to *P. spinosa* (see p. 192) but with few spines and stronger twigs, longer buds, and more prominent leaf-bases and pubescent.

ξ ξ *Leaves conduplicate in bud; buds ovoid or conical and pointed, especially the terminal one; twigs of various shades of brown, all glabrous and with round pith.*

ℵ *Twigs slender and pendent, yellowish grey passing to deep brown, with no special odour.*

Prunus Cerasus, L. Cherry (Fig. 128). The buds are small and nearly obtuse, the lateral ones erect, with dry brown scales; twigs glabrous, with no peculiar odour. Bud-scales smooth, or papillate under the lens. Lenticels scattered. Leaf-scar semi-lunate, with three leaf-traces on rather prominent leaf-bases.

ℵℵ *Twigs more erect and stouter, with more prominent leaf-bases; buds larger, more acute, and especially prone to be aggregated on the numerous dwarf-shoots.*

Prunus Avium, L. Gean (Fig. 129). *P. Avium* has larger and more pointed buds, stouter and more erect twigs with prominent leaf-bases, and more numerous dwarf-shoots; the latter thick and short and much ringed, and with buds clustered at their tips. The lenticels are also more prominent and the leaf-scars rounded triangular.

The bud begins with two scales, right and left, one overlapping the other at the margins; the third scale is anterior. Then follow about 6—8 others, each oval-pointed, and showing no trace of separation into parts. Further inwards we find the tips more rounded and notched, with a trace of lamina in the notch; and then obvious leaves with their stipules becoming narrower and more normal (Fig. 32). These leaves are conduplicate and spirally arranged.

As the bud opens, the outermost scales fall, leaving

Fig. 127. Bullace, *Prunus spinosa*, var. *insititia*, p. 243 (D).

Fig. 128. Cherry, *Prunus Cerasus*, p. 244 (D).

scars in spirals; the inner scales, graduating to leaves, fall later, leaving only the typical stipulate leaves.

It is generally difficult, and sometimes extremely difficult, to determine the buds of the various species of *Prunus* and *Pyrus* and allied genera. The green or olive, fat buds, usually larger at the apex, are characteristic of *Pyrus Aria*, *P. torminalis*, &c., but this does not apply to the Rowan, Apple and Pear; the buds of *Prunus* are usually more ovoid or ellipsoid, with more numerous matt-brown, dry scales. A good general distinction is found in the leaf-scars, which are usually narrow-crescentic and extended some distance round the twig in *Pyrus* (Fig. 59 *g*), but semi-lunate or nearly elliptical in *Prunus* and very slightly extended (Fig. 59 *q*). The periderm also differs in the two genera, and the exudations of gum, so common in *Prunus*, are not found in *Pyrus* and its allies: in *Prunus* the

Fig. 129. Gean, *Prunus Avium*, p. 244 (D).

periderm is usually very dark red to nearly black as it ages, with peeling thin papery laminæ in *P. Cerasus* and *P. Avium*, or splitting into long fissures in *P. domestica* &c., whereas in *Pyrus* it passes to greyer and duller hues and is more inclined to crack into scales. The smoother periderm of *Prunus* is also apt to drag out the lenticels into horizontal streaks.

In critical cases recourse may be had to the wood. In *Prunus* the annual rings are accentuated by the crowding of more numerous vessels in the spring wood, and the medullary rays are sharp, though thin: in *Pyrus* the vessels are uniform in distribution as well as in size, and, like the medullary rays, so fine that a lens is necessary to see them clearly.

§§ *Buds only showing one scale, really composed of two fused, as indicated by the keeled margins. Leaf-scar crescentic, with* 3 *leaf-trace bundles.*

[Other buds only exposing one scale are rare, e.g. *Guelder Rose*, pp. 168 and 169.

The Willows are so prone to vary and hybridise that it is impossible to do more here than indicate the principal types; even good species are not always determinable by the twigs and buds, but the following are the chief forms met with in Britain. Care must be taken in winter that the presence of superficial fungi is not confounded with hairiness.

The true terminal bud is usually aborted in the Willows. The lateral bud always starts with one scale, anterior, and completely covering the whole. This is doubtless composed of two fused leaves, because minute buds are sometimes found in their axils, to right and left of the ordinary bud.

Thereon follow two leaves standing right and left. The next leaf is anterior and begins the spiral.

Salix purpurea is exceptional in that the succeeding leaves may be opposite, though here also it may pass to a spiral arrangement.]

‡ *Twigs prostrate, rooting at the nodes, slender, not nodulose; buds and shoots silky pubescent; older buds and twigs red or red-brown, glabrous.*

Salix repens, L. Creeping Willow. Buds equal in size, long-ovoid, erect, appressed, pubescent, on slightly projecting leaf-bases, pith angular. Older branches smooth, glistening purple-brown or yellow.

This small shrub varies considerably, but neither the varieties nor the following rarer creeping species can be dealt with in detail here—*S. lanata*, *S. Lapponum*, *S. Myrsinites*, *S. reticulata*, and *S. herbacea*, all of which except the last two have densely silky or tomentose shoots or buds. Strongly growing shrubs of *S. repens* have ascending twigs, not rooting.

‡‡ *Twigs erect, long, slender, and withy as a rule, or much branched.*

÷ *Twigs, especially about the third year, purple with a waxy bloom; cortex bright yellow inside; buds thin, flat, narrow and appressed.*

S. daphnoides, Vill. Glaucous Willow. Twigs passing from pale olive-green, or green touched with red, to deep claret-purple, quite glabrous but pruinose: tips of young shoots with caducous silky puberulence; buds pale reddish to deep purple, very thin and flat, with parallel edges giving them a chisel-shape, closely appressed on ledge-

like projecting leaf-bases, the tips sometimes re-curved. There is no other species thus pruinose purple.

÷ ÷ *Twigs devoid of waxy bloom and bright yellow inner cortex.*

8 *Twigs golden yellow, smooth and polished, except at the slightly silky tips; buds elongated, small, appressed and flat, slightly silky.*

S. alba, var. *vitellina.* Golden Osier. A cultivated Osier. Shoots silky, as are the young buds. Older twigs passing to orange. In other respects resembling its parent form, *S. alba,* p. 253.

8 8 *Twigs not bright yellow.*

△ *Buds and twigs smooth; the latter easily snapping across just above the articulation, elsewhere tough and supple.*

S. fragilis, L. Crack Willow (Fig. 130). Buds triangular to long-ovoid, pointed, smooth, flat, reddish or with a violet hue to deep brown or nearly black, slightly keeled, more or less appressed, the nearly black-brown scales being greenish brown at the base and glabrous. Twigs glabrous, slender, more or less angular, red and green, or somewhat orange, when young passing to grey-yellow, olive, or purple-brown.

S. Russelliana, Sm., is a form with even more orange-coloured twigs, and the same violet-hued buds, but does not snap at the joints.

S. triandra, the Almond Willow (Fig. 131), has the same peculiarity of snapping above the articulation, but less easily, at any rate in some forms—e.g. var. *decipiens,*

Fig. 130. Crack Willow, *Salix fragilis*, p. 249 (Sc).

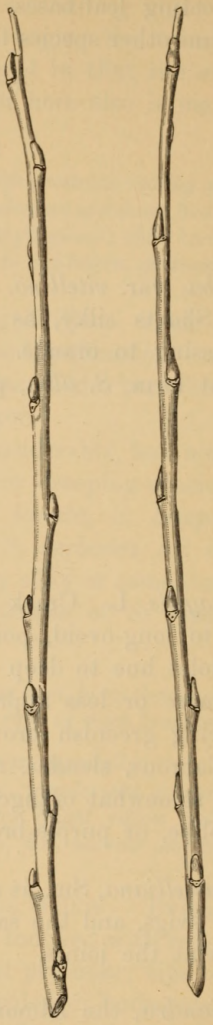


Fig. 131. Almond Willow, *Salix triandra*, p. 249 (Sc).

vide Buchanan White, p. 350. The twigs are somewhat angular above, smooth and polished, olive to purplish brown—i.e. green touched with red and brown. Buds elongated, with parallel edges, narrow and flattened at the apex which may be slightly re-curved. Lateral twigs poorly developed. In its typical form the Almond Willow when bruised has a faint odour of almonds.

ΔΔ *Twigs not particularly apt to snap at the articulations.*

𝒹 *Buds sub-opposite, long, narrow, shining and appressed, but not flattened; scale easily detached.*

S. purpurea, L. Purple Willow (Fig. 132). Sending up long, erect and very slender withes, glabrous and shiny, rather pale in colour at first, but passing from greenish or reddish olive (olive-green to red-brown) to deep claret-purple or yellowish grey-green. Buds pale red-violet or shining red to purple-black, small and long, narrow, flat and appressed, sub-cylindric and crowded, a large proportion sub-opposite; those on the upper parts of the twig smaller than those lower down, averaging 4×1. Bud-scale greenish brown to purple-red or black, easily detached and exposing the silky contents. Pulvinus prominent. Lateral shoots thin and poorly developed. There is often a pair of buds at the end of the shoot with the dead apex between. Lenticels few and small.

𝒹𝒹 *Buds not sub-opposite; scale not remarkably detachable.*

Z *Buds and shoots, and often twigs as well, distinctly hairy.*

> *Buds pubescent-silky, not tomentose.*

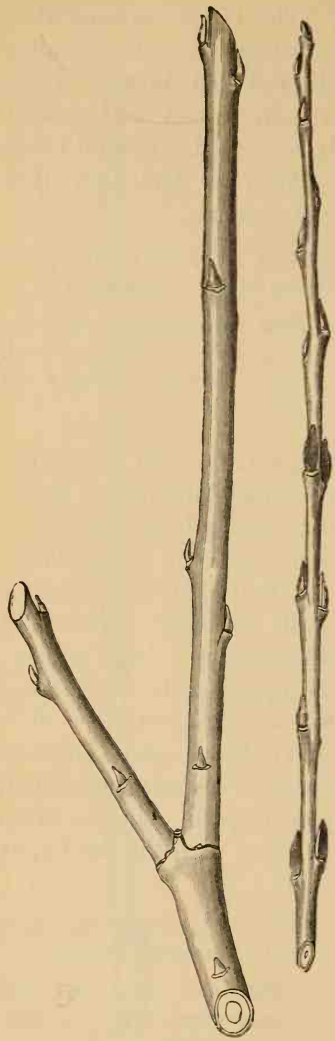


Fig. 132. Purple Willow. *Salix purpurea*, p. 251 (Sc).

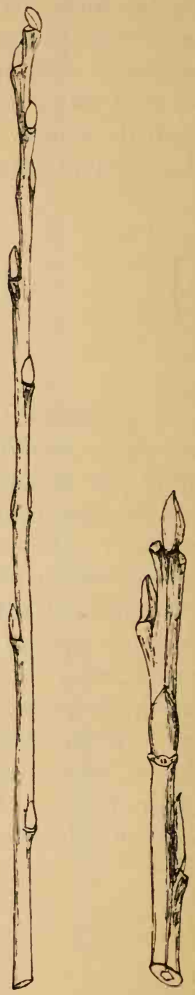


Fig. 133. White Willow, *Salix alba*, p. 253 (D).

ʒ *Buds and young shoots whitish with silky appressed hairs; twigs long and withy.*

S. alba, L. White Willow (Fig. 133). Twigs usually retaining the silky pubescence at the tips, rather polished olive-brown, or passing to glabrous yellow and olive, reddish grey or brown, to purple or nearly black, rather slender and supple. Buds with parallel sides, flattened and small, strongly appressed and straight, the tips not curved outwards, pubescent-silky.

The variety *vitellina*, with golden yellow twigs, has been dealt with (p. 249). The Purple Osier is a variety with deep olive-purple twigs. One form is known locally as the Huntingdon Willow.

There is a good deal of variation in the amount of pubescence, and sometimes difficulty occurs with the somewhat similar, but normally not silky, *S. fragilis* (p. 249), the fragility of the twigs not being absolutely distinctive in frosty weather.

ʒ ʒ *Young twigs somewhat pubescent, but soon glabrous and shining olive or brown; buds yellow or orange-greenish, slightly silky; twigs short and much branched.*

S. Phylicifolia, L. Tea-leaved Willow. Buds greenish orange or yellow, obtuse, slightly silky pubescent, on close-set projecting leaf-bases, giving a nodulose appearance to the twiggy shoots; the latter olive-green to brown, or maroon, at length glabrous and shining. Buds obtuse, convex, appressed and often with re-curved tips: sometimes in pairs.

>> *Buds velvety and twigs tomentose, not silky; appressed or tips incurved.*

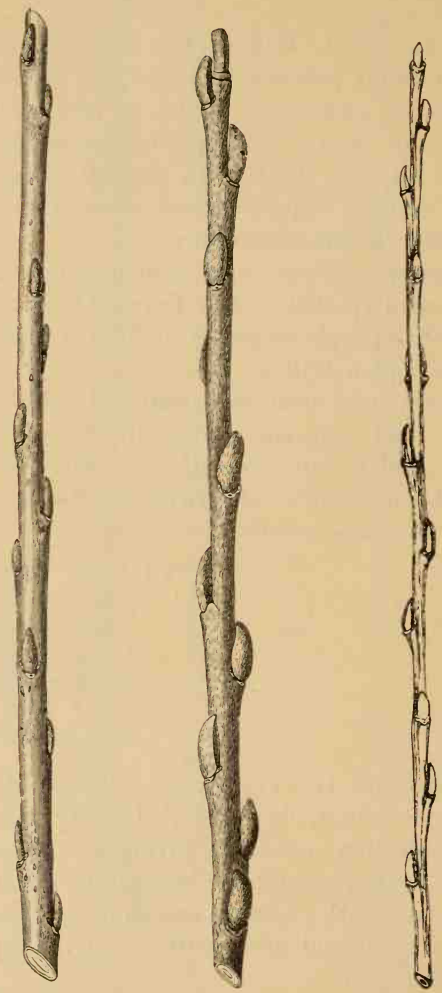


Fig. 134. Osier, *Salix viminalis*, p. 255 (D and Sc).

ξ *Buds very small, thin and narrow, appressed; leaf-bases not prominent; twigs long and slender.*

S. viminalis, L. Osier (Fig. 134). The twigs are velvety, not silky, greenish yellow or olive-tawny to yellowish brown, passing through olive or olive-brown to maroon, polished, and often very long, slender, and supple; the tips remaining slightly velvety and angular. Lenticels few. Buds very small, thin, narrow, appressed, somewhat tomentose, puberulent; often in pairs, side by side, towards the apex of the twig, which may become smooth lower down.

ξ ξ *Buds larger and convex, erect; not thin and flat-appressed; shoots and buds grey velvety-tomentose.*

χ *Twigs deep purple-black or olive, velvety; the older smooth purple-black.*

S. nigricans, Sm. Black Willow. This, probably a variety of *S. Phylicifolia,* has the twigs of two to three years old nearly black-purple or olive, passing from velvety or glandular hairy to smooth and shining; buds convex, hardly appressed, densely velvety. Twigs longer and less branched or tufted than *S. Phylicifolia,* and leaf-bases not prominent. There is the same tendency to have pairs of buds in the axils. Younger twigs rounded, olive-brown to red-brown, with scattered lenticels.

χ χ *Buds ovoid, large, like* S. Caprea, *but they and the twigs remain soft and velvety pilose, and more or less tawny or red.*

S. Caprea, var. *cinerea*, Grey Willow (Fig. 135). A variety or sub-species of the group *S. Caprea* and *S. aurita*, the hoary shoots inclining to dark fuscous, rather robust, with shallow rills at the tips, and soft to the touch owing to the dense grey tomentum on buds and tips, passing to smooth. Intermediate between *S. Caprea* and *S. aurita*, and with similarly shaped and disposed buds. The twigs are, however, thinner and more branched, and the buds smaller and more nodulose.

ZZ *Buds and twigs glabrous, though the tips of the shoots may be slightly pubescent.*

> *Buds and twigs polished brown, as if varnished, and quite glabrous.*

S. pentandra, L. Bay Willow. Buds erect, more or less appressed, ovoid, the upper larger than those towards the base of the shoot, and reminiscent of *S. Caprea*; bud-scales polished brown, or the base greenish. Colour of twigs passing into green.

[*S. pentandra*, L., is said by Bentham to have green or yellow twigs. Its upper buds are reminiscent of *S. Caprea*, but they are browner. It presents difficulties also with *S. triandra*, the twigs of which tend to be more angular above, and the buds to be more pubescent. Buchanan White has indicated some confusion between this plant and *S. fragilis*, L., and it may be doubted whether the points of difference furnished by the polished brown twigs can be relied on.]

>> *Buds red, or tawny yellow with reddish flecks, convex.*

S. Caprea, L. Sallow (Fig. 136). Twigs nodose with projecting leaf-bases, and leaf-scars large for a willow;

Fig. 135. Grey Willow, *Salix Caprea*, var. *cinerea*, p. 256 (Sc).

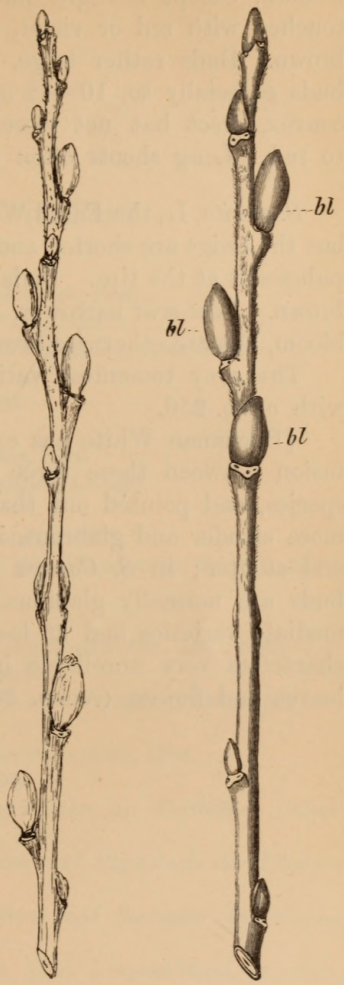


Fig. 136. Sallow, *Salix Caprea*. The larger buds *bl* are flower-buds, p. 256 (D and Sc).

smooth, except a slight puberulence at the tip, green touched with red or violet, passing to olive- or purple-brown. Buds rather large, 5—6 mm. long, the flower-buds especially so, 10—12 mm., keeled at the margins, convex, erect but not closely appressed, orange tawny to red. Long shoots often thick.

S. aurita, L., the Eared Willow, is much like *S. Caprea*, but the twigs are shorter and more slender, and caducous pubescent at the tips. Buds less pointed and darker red-brown. Leaf-scar narrower. The twigs may have a grey bloom, but are otherwise brown, passing to greenish grey.

The grey tomentose variety, *cinerea*, has been dealt with on p. 256.

[Buchanan White has examined the sources of confusion between these three forms which he accepts as species, and pointed out that in *S. aurita* the twigs are more slender and glabrous, in *S. cinerea* more pubescent and stouter; in *S. Caprea* the one-year-old twigs and buds are normally glabrous. At the same time intermediate varieties and at least three hybrids render the characters very unreliable in detail, in the absence of leaves and flowers (see p. 256).]

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INDEX.

Abele 227
Abies 30, 95
A. pectinata 31, 109, 139
Abietineæ 28
Aborted buds 64, 68, 113, 114, 115, 142, 174
Absciss-layer 100, 105, 116
Accessory buds 23, 26, 30, 33, 34, 36, 37
Accessory characters of twigs 124
Acer 28, 37
A. campestre 25, 109, 110, 126, 155, 169–171
A. Negundo 94
A. platanoides 25, 109, 110, 111, 154, 155, 171
A. pseudoplatanus 27, 155, 156, 171
Acicular leaves 133, 137
Adventitious buds 36, 40
Æsculus 16, 25, 28, 93, 223
A. Hippocastanum 150, 151
Aggregations of buds 30, 34, 37, 148, 216
Ailanthus 53, 55, 59, 97, 98, 110, 111, 112, 116, 117, 118, 119, 123
A. glandulosa 57, 117, 211
Albizzia 37
Alder 26, 27, 33, 36, 39, 52, 53, 55, 59, 62, 63, 71, 95, 96, 109, 111, 112, 118, 119, 121, 122, 125, 206, 207
Alder Buckthorn 33, 50, 215
Almond 33, 80, 110, 111, 116, 119, 121
Almond Willow 249, 251
Alnus 125, 223
A. glutinosa 27, 206, 207
Aloe 83
Alternate buds 30, 31, 33, 174–258
Alyssum 86, 90
Ampelideæ 91
Ampelopsis 53, 55, 109, 121, 130, 188, 189
A. hederacea 117
Analysis of buds 41
Angle of insertion 36, 40
Annual growth 64, 71, 73
Apex of stem 10, 11, 66
Apple 33, 52, 53, 55, 59, 61, 80, 88, 96, 110, 111, 116, 117, 119, 121, 126, 143, 229, 230, 246
Arbor Vitæ 68, 142
Arbutus 55, 59, 63
Aristida 93
Aristolochia 37, 55, 59, 63
A. Clematitis 94
A. Sipho 26
Armed plants 144, 145, 159–162, 189–204
Aroids 26, 85
Arolla Pine 134
Arrangement of buds 30, 36
Arrangement of bud-scales 29, 49, 54
Arrangement of leaves in bud 29, 58
Arrangement of leaf-scars 116
Arrangement of leaf-traces 119
Artemisia 89, 90
Asclepiadeæ 93
Ash 14, 18, 23, 25, 26, 27, 29, 30, 31, 39, 52, 53, 54, 59, 60, 71, 80, 109, 112, 114, 116, 118, 119, 121, 152, 153
Aspen 39, 68, 71, 109, 110, 112, 114, 117, 219, 220
Aster 90
Atragene 102

Aubretia 89, 90
Aucuba 30, 111, 144, 149
A. japonica 144
Austrian Pine 136
Axil 6, 7
Axillary buds 7, 13, 19, 23, 26, 28, 30, 36, 78, 105
Axis 9
Azalea 51, 54, 55, 59, 61, 110, 114, 123, 125, 223

Barberry 5, 33, 50, 53, 55, 77, 80, 97, 98, 108, 109, 111, 114, 116, 117, 121, 123, 128, 129, 199, 200
Bark 94, 96, 98
Basal buds 38
Bay Willow 256
Beam Tree 52, 53, 55, 111, 114, 119, 121, 122
Bean 29
Beech 5, 21, 22, 25, 26, 27, 29, 30, 32, 36, 39, 40, 42, 44, 53, 54, 55, 56, 57, 59, 62, 63, 69, 71, 72, 73, 75, 76, 77, 78, 79, 80, 93, 95, 97, 98, 108, 109, 111, 114, 115, 116, 117, 119, 121, 126, 175–177
Begonia 84, 85, 91
Berberis 96, 127
B. vulgaris 199, 200
Betula 188
B. alba 232, 233, 234
B. glutinosa 223, 234
B. nana 110, 112, 234
B. pubescens 27, 231, 234
B. verrucosa 27, 233
Bifoliar spurs 18
Bilberry 55, 59
Birch 29, 32, 36, 39, 52, 53, 55, 57, 59, 63, 68, 71, 80, 95, 97, 98, 108, 110, 111, 112, 114, 116, 117, 118, 119, 121, 122, 123, 125, 126, 188, 189, 232, 233
Bird Cherry 31, 33, 52, 54, 55, 60, 74, 80, 111, 116, 117, 119, 121, 123, 241, 242
Bittersweet 50, 53, 55, 109, 123
Blackberry 33, 52, 53, 55, 60, 110, 111, 112, 117, 119, 127, 203
Black Currant 33, 53, 55, 63, 108, 117, 119, 122, 207, 208
Black Mulberry 110, 111
Black Pine 136
Black Poplar 39, 40, 45, 56, 61, 109, 110, 111, 114, 117, 125, 221, 222
Black twigs 112
Black Willow 255
Blackthorn 5, 33, 53, 60, 61, 80, 108, 111, 112, 116, 119, 121, 122, 126, 128, 130, 162, 192, 193
Blade of leaf 11
Bloom 83, 124
Boehmeria 90
Borragineæ 90
Box 143
Bramble 202
Branch 3, 5, 26
Branch-tendrils 130
Branched hairs 90
Branching 28, 76
Bristles 90, 124, 127
Broad Bean 29
Bromelia 90
Bronzed twigs 110, 190
Broom 55, 59, 63, 116, 117, 123
Brown twigs 110
Brussels Sprout 9, 15, 21, 49
Buckthorn 52, 53, 55, 108, 116, 117, 119, 121, 122, 123, 159, 160, 161
Bud 6, 7, 9, 23, 113
Bud-coverings 23, 27
Bud of buds 18, 19, 20
Bud-scales 9, 13, 15, 16, 21, 23, 27, 49
Bud-sections 9, 29
Bullace 243, 245
Buried buds 23, 25, 35, 113, 122, 213
Burnet Rose 204
Bursting of bud 16, 21, 64
Butcher's Broom 150
Buxus sempervirens 143

Cabbage 9, 10, 12, 15, 49, 83
Cactus 83
Calcium carbonate 90
Calluna 142
Camellia 55, 59
Canadian Poplar 109, 110, 111
Capitate hairs 91
Carpinus 27
C. Betulus 177, 178

Carya 37
Caryophyllaceæ 91
Castanea 177
C. vesca 187, 188
Cedar 36, 51, 54, 59, 63, 68, 77, 80, 116, 121, 123, 137, 206
Cedar of Lebanon 137
Cedrus Atlantica 137
C. Deodara 137
C. Libani 137
Celastrus 37
Cell-contents 81, 85
Cell-sap 85
Cell-walls 82
Cellulose 83
Celtis 55
Centaurea 86
Cercis 29, 37
C. canadensis 37
C. gymnocladus 26
C. siliquastrum 37
Ceroxylon Klopstockia 84
Cherry 31, 33, 34, 52, 53, 55, 59, 60, 95, 108, 110, 111, 116, 117, 119, 121, 123, 244, 245
Cherry Laurel 52, 59, 60, 111, 149, 150
Chestnut 32, 52, 53, 55, 59, 63, 95, 96, 109, 110, 112, 118, 119, 122, 126, 150, 184, 187, 188
Chlorophyll-corpuscles 85
Ciliate leaf 44, 126
Circular leaf-scars 117
Cistaceæ 90
Cladastris 25
Classification 133
Clematis 30, 53, 96, 109, 110, 112, 123, 129
C. vitalba 162
Clerodendron 37
Climbers 162
Climbing organs 124
Coexistence of long and dwarf-shoots 76
Coffee 59
Collateral buds 26, 30, 33, 37
Colleters 91
Colour of bud-scales
Coloured hairs 125
Coloured cell-sap 85
Colours of twigs 94, 107, 109, 112
Compositæ 91, 93
Compound bud 9, 133
Conduplicate leaf 46, 58, 60, 69
Cone 133, 137
Conifers 29, 133–142, 204
Continuity of vascular system 100, 102
Convolute leaf 58, 60, 61
Convolvulus 86
Coppery lustre 125, 190
Coriaceous 143
Cork 82, 94, 96, 98, 104
Cork-cambium 98
Cork-layer 95
Cork Oak 149
Cork-warts 96, 97, 113, 122
Cornus 37, 51
C. mas 26, 95
C. sanguinea 55, 110, 126, 169, 170
Correa 89, 90
Corylus 150, 177
C. Avellana 184, 185
Cotoneaster 53, 111, 112, 126, 229, 231
C. vulgaris 231
Cotyledons 3, 6, 7, 13
Cottony hairs 126
Crab Apple 229
Crack Willow 109, 249, 250
Cratægus 80
C. Oxycantha 194, 195
Creeping Willow 248
Crescentic leaf-scars 117
Cruciferæ 90
Cupressus sempervirens 142
Currant 23, 95, 108
Cuticle 81, 83
Cuticularised walls 83
Cutin 82
Cutting sections 48
Cydonia 25, 126
C. vulgaris 229
Cypress 68, 116, 123, 142
Cytisus Laburnum 224

Daphne 27, 51, 53, 55, 59, 63, 116, 117, 119
D. Laureola 148, 149
D. Mezereon 109, 110, 111
Datura 93
Deciduous plants 150
Decussate buds 31, 115, 150

Decussate bud-scales 49, 54
Decussate leaves 58
Deep-seated periderm 96
Development of shoot 64
Diagram of bud 45–48
Dicotyledons 82, 142
Different kinds of shoots 76
Digestive hairs 92
Direction of leaves in bud 58, 60
Displaced buds 26, 30, 32, 174
Dissection of bud 9, 15, 18, 21, 41, 43
Distichous buds 30, 31, 174–189
Distichous bud-scales 43, 46, 49, 55
Distichous leaves 58
Dog Rose 201
Dogwood 30, 53, 54, 59, 108, 110, 111, 112, 115, 117, 119, 122, 169, 170
Dormant buds 36, 38, 39
Douglas Fir 34, 37
Downy hairs 126
Downy Rose 204
Draba 87, 90
Drosera 92
Dwarf Birch 110
Dwarf-shoots 17, 18, 19, 76, 79, 80, 113, 120, 122, 128, 204

Eared Willow 258
Eglantine 202
Elæagnaceæ 90
Elæagnus 27, 89, 108, 111, 125
E. augustifolia 192
Elder 30, 33, 50, 52, 53, 54, 95, 96, 108, 109, 112, 115, 116, 119, 122, 158
Elliptical leaf-scars, 117
Elm 9, 21, 29, 32, 39, 46, 52, 53, 55, 59, 60, 68, 80, 95, 109, 110, 111, 112, 114, 116, 117, 118, 119, 121, 122, 126, 150, 180–184
Embryo 3
Emergences 81, 92
Ends of growing shoots 41, 43
Epicormic shoots 36, 39
Epicotyl 6, 13
Epidermis 81, 84, 107
Epiphytes 124
Erica 142
Ericoid 142
Eriodendron 93
Eriophorum 93
Euonymus 51, 94, 108
E. europæus 171, 172
Euphorbia 83
Evergreen Oak 219
Evergreens 133
Expansion of leaves 66
Extension of shoots 64, 66, 71
Extra-axillary buds 23, 26
Extra buds 33, 37

Fagus 44
F. sylvatica 62, 175, 176
Fall of leaf, 100, 104, 105
False Acacia 197
False dichotomy 28, 113, 115
False whorls 31
Fern-prothallia 85
Ferns 85
Fibres 100
Fibro-vascular skeleton 100, 102
Ficus 25, 84
F. Carica 209
F. elastica 27
Field Rose 202
Fig 23, 51, 52, 53, 55, 59, 63, 110, 112, 114, 116, 118, 119, 123, 209
Fir 11, 20, 21, 25, 34, 51, 53, 55, 59, 63, 68, 116, 123, 138
Fissured surface 127
Five-needled Pines 133
Five-ranked buds 32
Five-ranked bud-scales 47, 59, 148
Flaking of epidermis 94
Flower-buds 15, 16, 26
Fly Honeysuckle 166, 167
Folding of leaves in bud 58, 60, 63
Forked hairs 90
Forking of twigs 28, 115
Formation of bud 23
Forms of hairs 86, 89
Fraxinus 25, 37
F. excelsior 152, 153
Functions of cuticle 81, 83
Functions of bud-scales 15, 27, 49, 56
Functions of hairs 85, 90, 91
Furze 33, 111, 116

Gean 244, 246

Genista 119, 190
G. anglica 128, 190
G. tinctoria 117
Ginkgo 80
Glabrous surface 127
Glands 81
Glandular hairs 91, 125
Glaucous Willow 248
Gleditschia 25, 26
Glistening surface 127
Gloxinia 86
Gnaphalium 86, 87
Goat Willow 256
Golden Osier 109, 249
Gooseberry 33, 53, 55, 92, 108, 111, 122, 126, 127, 128, 197, 198
Gorse 126, 128, 145, 190
Gossypium 90, 93
Gourmandizers 39
Gramineæ 29
Grape 83
Grasses 84
Green twigs 111
Grey twigs 108
Grey Willow 257
Growth of shoot 64, 71
Guelder Rose 30, 52, 53, 54, 108, 109, 110, 115, 117, 119, 122, 167, 247
Gymnogramme 84

Hairiness 124, 125
Hairs 81, 85, 91, 124, 126, 127
Half-moon-shaped leaf-scars 117
Half-open buds 50
Hamamelis 63
Hardening of buds 47
Hawthorn 26, 33, 40, 53, 55, 74, 108, 109, 111, 112, 116, 119, 121, 122, 128, 130, 142, 194, 195
Hazel 29, 32, 52, 53, 55, 59, 60, 68, 74, 80, 91, 95, 97, 98, 109, 111, 114, 119, 122, 123, 125, 183–185, 187
Heart-shaped leaf-scars 117
Heath 96, 142
Hedera Helix 146, 147
Hippophaë 27, 53, 90, 118, 125, 128, 234
H. rhamnoides 191
Holly 5, 31, 51, 55, 59, 63, 111, 127, 144, 145, 148
Holme Oak 148
Honeysuckle 30, 50, 51, 54, 59, 63, 96, 109, 110, 111, 112, 116, 117, 119, 122, 123, 129, 159, 163
Hop 53, 91
Hornbeam 21, 22, 26, 29, 32, 36, 39, 40, 52, 54, 55, 59, 63, 68, 72, 74, 80, 95, 97, 98, 108, 109, 111, 114, 115, 117, 118, 119, 121, 126, 177–179, 183, 184
Horse-chestnut 15, 17, 19, 23, 25, 27, 28, 30, 52, 53, 54, 56, 57, 59, 75, 91–95, 96, 104, 109, 110, 111, 114, 115, 116, 117, 118, 119, 122, 125, 150–152
Huntingdon Willow 253

Ilex Aquifolium 144, 145
Immersed buds 35, 113, 122
Intermediate scales 16, 66
Internodes 3, 5, 10, 11, 12, 13, 64, 66, 73, 120
Involute leaf 45, 46, 58, 61
Ivy 4, 32, 50, 55, 59, 63, 112, 129, 146, 147

Jasminum 33, 37
Juglans 27, 37
J. cinerea 26
J. regia 70, 211, 212
Juniper 27, 50, 54, 58, 63, 110, 123, 141
Juniperus communis 141

Kidney-shaped leaf-scars 117
Koniga 86

Labiatæ 91
Laburnum 33, 52, 53, 55, 80, 87, 110, 111, 112, 116, 117, 119, 121, 123, 126, 224
Lamina of leaf 11
Lammas shoots 64, 75
Larch 31, 36, 39, 51, 54, 55, 59, 63, 68, 71, 77, 80, 96, 99, 109, 110, 111, 116, 119, 121, 123, 137, 204, 205
Larix europæa 204, 205
Lateral buds 13
Lateral displacement of buds 32

Latex 169, 209
Laurel 144, 149
Laurus 37, 59, 63, 144, 149
Leader 64, 71
Leaf 3, 5, 9, 13
Leaf-bases 17, 50
Leaf-buds 26
Leaf-casting 100, 104
Leaf-cushion 128
Leaf-insertions 101
Leaf-scales 49, 51
Leaf-scars 79, 80, 100, 106, 113, 116, 118
Leaf-spines 129, 199
Leaf-stalk 11, 101, 105
Leaf-tendrils 129, 162
Leaf-trace bundles 106, 113, 119
Leaf-traces 106, 117, 119
Lenticels 94, 96, 97, 113, 122
Lettuce 9, 10, 12, 21, 25, 49
Ligustrum vulgare 144, 173
Lilac 12, 14, 17, 23, 27, 28, 30, 41, 42, 51, 53, 54, 59, 63, 109, 110, 111, 112, 115, 122, 157, 173, 174
Liliaceæ 29
Lime 29, 32, 36, 39, 41, 43, 48, 52, 53, 55, 57, 59, 60, 68, 72, 80, 95, 110, 112, 114, 117, 118, 119, 121, 123, 186
Limits of seasonal growth 73
Linear leaf-scars 117
Ling 80
Liriodendron 27, 60
Loblolly Pine 134
Lombardy Poplar 39
Long shoots 76, 77, 78, 80
Longitudinal sections of bud 11, 17, 20, 35
Lonicera 27, 37, 55, 57
L. Caprifolium 163, 164
L. Periclymenum 163, 164, 166
L. tartarica 26
L. Xylosteum 40, 108, 166, 167
Lotus 83
Lupulin 91
Lycium 37, 50, 108

Magnolia 25, 27, 53, 56, 59, 60
Mahonia 145
Maple 17, 23, 30, 33, 39, 52, 53, 54, 57, 59, 63, 68, 96, 111, 112, 114, 115, 117, 118, 121, 122, 169, 170
Marks on winter twigs 113
Maximum extension 64, 72, 74
Mealy hairs 126
Measurements of growth 71, 74
Mespilus 128
M. Germanica 196
Metallic lustre 111, 125
Methods of bud analysis 41, 47
Mistletoe 4, 29, 30, 50, 54, 59, 63, 84, 94, 98, 107, 112, 129, 142
Mixed buds 26
Monstera 26
Morus 42, 210
M. Alba 210
M. nigra 109, 110, 210
Mossy-cupped Oak 216
Mountain Ash 225
Mucilage 81, 83
Mulberry 33, 34, 42, 53, 55, 59, 63, 114, 118, 119, 210
Multicellular hairs 89, 90
Myrica 52, 96, 125
M. cerifera 84
M. Gale 234

Naked buds 15, 27, 49, 50, 147, 164, 210
Needles 18, 133
Nepenthes 92
Node 3, 5, 64, 66, 73, 120
Norway Maple 54, 73, 154, 155
Numbers of bud-scales 19, 25, 49, 53
Numbers of buds on shoot 36
Numbers of leaves in bud 23
Numbers of leaf-traces 119

Oak 5, 7, 23, 25, 27, 28, 29, 31, 33, 34, 37, 39, 47, 52, 54, 55, 56, 57, 59, 60, 69, 71, 75, 93, 95, 108, 109, 111, 114, 115, 117, 118, 119, 121, 143, 216–219
Old Man's Beard 162
Olive twigs 111, 112
Open buds 50, 158
Opening of bud 14, 21, 27, 41, 44, 64, 68
Opposite buds 30, 31, 37, 115, 142, 150–174

Opposite bud-scales 42, 46, 49, 54
Opposite leaves 11
Origin of periderm 94, 96
Osier 249, 254, 255
Outgrowths of epidermis 81

Palm 29, 84, 93
Pansy 92
Papaya 29
Pappus 93
Parasitic plants 124, 129, 142
Pear 33, 52, 53, 55, 59, 61, 80, 96, 109, 110, 111, 114, 116, 117, 119, 121, 122, 128, 239, 240
Peeling of epidermis 94
Peltate scales 90, 91
Perfoliate Honeysuckle 163
Periderm 94, 96, 98, 107
Periodic growth 64, 75
Persistent epidermis 81, 94
Perulæ 19, 133
Petiole 11, 101, 105
Petty Whin 190
Philadelphus 25, 35, 96, 122, 197
P. Coronarius 96
Philodendron 29
Phlomis 90
Picea 30
P. excelsa 20, 31, 139
Pilose hairs 126
Pine 7, 9, 17, 18, 19, 20, 21, 25, 28, 31, 34, 36, 51, 53, 54, 55, 57, 59, 63, 68, 77, 80, 96, 99, 116, 121, 123, 133
Pinguicula 92
Pinus Austriaca 136
P. Cembra 126, 134
P. excelsa 134
P. Laricio 136
P. montana 136
P. monticola 134
P. Pinaster 136
P. Pinea 136
P. Strobus 134
P. sylvestris 109, 135, 136
P. Taeda 134
Piperaceæ 91
Pith 212
Plan-diagram of bud 9, 41, 46
Plane 35, 52, 53, 56, 57, 59, 61, 95, 109, 112, 117, 118, 121, 122, 123, 127, 189, 213, 214
Plane leaf 58, 63
Platanus 25, 35, 189, 197
P. occidentalis 213, 214
P. orientalis 214
Plicate leaf 44, 58, 63, 70
Plum 33, 52, 54, 61, 80, 83, 110, 116, 117, 119, 121, 123
Plumule 3, 6, 7, 9, 12
Polished surface 127
Polygonum 37
Poplar 23, 24, 26, 33, 45, 53, 55, 59, 61, 68, 80, 93, 95, 96, 119, 121, 122, 142
Populus alba 108, 227, 228
P. canadensis 27, 109, 223
P. nigra 27, 45, 109, 221–223
P. pyramidalis 221
P. tremula 219, 220, 221, 227
Portugal Laurel 52, 150
Position of buds 25, 30, 36
Position of leaf-scars 116
Potentilla 88, 90
Prickles 5, 81, 92, 124, 127, 189, 199
Primary bud 3, 9, 13
Primary root 5, 6
Primary stem 6
Primulaceæ 91
Privet 51, 53, 54, 63, 97, 98, 109, 110, 115, 116, 117, 118, 119, 122, 144, 173, 174
Protective functions of bud-scales 23, 27
Pruinose twigs 112
Prunus 28, 34, 37, 55, 60, 68, 95, 96, 118, 126, 241–247
P. Amygdalus 60
P. Avium 25, 27, 50, 59, 60, 69, 108, 110, 111, 219, 244, 246, 247
P. Cerasus 60, 244, 245, 247
P. domestica 192, 242, 243, 247
P. insititia 126, 192, 231, 243, 245
P. Lauro-cerasus 149
P. Lusitanica 149, 150
P. Padus 34, 60, 126, 241, 242
P. spinosa 60, 162, 192, 193, 243, 245
Pseudo-distichous 137
Pseudo-terminal bud 113, 114
Pseudo-whorls 30, 31, 34, 133

Pseudotsuga Douglasii 139, 140
Puberulence 126
Pubescence 124, 126
Pulvinar spines 128, 129, 197
Pulvinus 128
Pungent leaf 141
Punica 37
Purple Osier 253
Purple twigs 112
Purple Willow 251, 252
Pyramidal Poplar 221
Pyrus 96, 118, 246, 247
P. Aria 111, 126, 224, 236, 237, 238, 246
P. Aucuparia 225, 226, 227
P. communis 196, 239, 240
P. Malus 229, 230
P. Sorbus 108, 111, 112, 223
P. torminalis 109, 111, 112, 235, 236, 246

Quercus Cerris 110, 112, 118, 126, 216, 218
Q. coccinea 110, 112, 218
Q. Ilex 148
Q. ilicifolia 26
Q. pedunculata 217
Q. pubescens 126, 218
Q. Robur 47, 216, 217
Q. rubra 111, 218
Q. sessiliflora 218
Q. Suber 149
Quick-growing shoots 72

Radicle 5, 6
Rapidity of growth 71
Raspberry 125, 202, 203
Recurrent growth 75
Red-berried Elder 159
Red Currant 33, 53, 55, 63, 108, 117, 119, 122, 209
Red Maple 26
Red Oak 117
Red twigs 110
Reduced leaves 18, 49, 51
Relations of leaf to shoot-axis 100
Replacement of epidermis 94
Resinous excretions 15, 56, 57, 81, 84, 91, 125
Revolute leaf 58, 61
Rhamnus 46, 80, 95, 96, 193
R. catharticus 31, 46, 59, 63, 111, 112, 128, 159, 160
R. Frangula 27, 51, 111, 112, 126, 215
Rhododendron 51, 54, 55, 56, 59, 61, 223
R. ponticum 149
Rhus 118, 123
R. typhina 25, 50, 111, 117, 119, 122, 126, 211
Ribes 96, 99, 108, 125
R. alpinum 209
R. Grossularia 197, 198
R. nigrum 109, 207, 208, 209
R. rubrum 209
Ricinus 93
Ring-shaped leaf-scars 117
Robinia 29, 33, 35, 39, 96, 99, 108, 110, 112, 122, 128, 197, 198
R. pseudacacia 25, 197, 198
Root-climbers 129, 146
Root-system 3, 4
Rosa 125, 202
R. arvensis 202
R. canina 201, 202, 204
R. rubiginosa 202
R. spinosissima 204
R. villosa 204
Rose 18, 33, 52, 53, 55, 59, 60, 92, 96, 110, 111, 112, 117, 118, 119, 127
Rose Bay 149
Rough bark 96, 99
Rowan 53, 55, 108, 109, 110, 111, 114, 117, 119, 121, 122, 126, 225, 226, 227, 246
Rubus 37, 92
R. fructicosus 145, 202, 203
R. Idæus 202, 203
R. odoratus 97
Rugose surface 127
Ruscus aculeatus 150
Rusty hairs 126

Salix 37
S. alba 87, 109, 111, 249, 252, 253
S. aurita 108, 111, 256, 258
S. Caprea 255, 256, 257, 258
S. cinerea 256, 257, 258
S. daphnoides 83, 112, 124, 248
S. decipiens 249

S. fragilis 109, 110, 111, 249, 250, 253, 256
S. herbacea 248
S. lanata 248
S. Lapponum 248
S. Myrsinites 248
S. nigricans 26, 126, 255
S. pentandra 109, 111, 256
S. Phylicifolia 253, 255
S. purpurea 31, 55, 59, 110, 111, 112, 169, 174, 248, 251, 252
S. repens 109, 110, 111, 248
S. reticulata 248
S. Russelliana 249
S. triandra 110, 249, 250, 256
S. viminalis 34, 88, 109, 111, 112, 126, 254, 255
S. vitellina 249, 253
Sallow 256, 257
Sambucus 37
S. nigra 26, 37, 158
S. racemosa 26, 33, 37, 109, 111, 159
Sarothamnus 53, 80, 111
Saxifragaceæ 91
Scabious 90
Scales 14, 125, 133, 141
Scaly buds 15
Scars of bud-scales 67, 78, 79, 80, 113, 120
Scars of cotyledons 7
Scars of leaves 14, 106, 113, 118
Scars of stipules 29
Scotch Fir 135
Scotch Rose 204
Scots Pine 39, 71, 72, 73, 111, 135
Sea Buckthorn 33, 108, 111, 116, 117, 119, 121, 122, 123, 191
Seasonal growth 72
Secondary growth 64
Sections of buds 9, 29, 41
Seed-leaves 6
Seedling 5, 6, 7, 9
Segmentation of shoot 3
Semi-lunate leaf-scars 117
Service Tree 235
Separation-layer of leaf 100, 105, 116
Setæ 90
Shaggy hairs 88
Shapes of buds 23, 25
Shapes of leaf-scars 113, 117, 118
Shield-shaped leaf-scars 117
Shining surface 127
Shoot, segmentation of 5
Shoots 64, 69
Shoot-system 3, 4, 7
Silicified hairs 90
Silky hairs 86, 88, 90, 126
Silver Fir 28, 31, 33, 34, 37, 39, 54, 57, 71, 72, 73, 138, 139
Silvery lustre 125, 190
Simple bud 9, 49, 137
Sizes of buds 23, 25, 113, 114
Sizes of leaf-scars 113, 116
Skeleton of shoot 102
Slate-coloured twigs 109
Slow-growing shoots 72
Smooth bark 96, 99
Snowberry 173
Sophora 37
Sorb 119, 223
Spiudle Tree 30, 53, 54, 59, 63, 94, 109, 110, 111, 112, 115, 116, 119, 171, 172
Spines 5, 124, 127, 128, 129, 189, 196
Spinescent 144
Spinose organs 127
Spiræa 37, 96
Spiral buds 30, 32, 33, 189
Spiral bud-scales 19, 49, 55
Spiral leaves 11, 58
Spruce 9, 20, 21, 31, 34, 37, 39, 54, 56, 71, 72, 73, 111, 139
Spurge Laurel 148, 149
Spurs 76, 77, 113, 120, 122, 133
Stalked buds 26, 206
Staphylea 54, 61, 115
Starved buds 38
Stellate hairs 86, 88, 90
Stellate scales 86
Stem 3, 6
Stipa 93
Stipular bud-scales 21, 22, 24, 42, 45, 47, 51, 52, 62, 174
Stipular spines 128, 129, 197
Stomata 82, 85
Striate surface 127
Structure of bud-scales 49, 56
Structure of epidermis 81, 84
Sub-evergreen 144, 173
Submerged buds 25, 30, 35, 113, 122, 213

Sub-opposite buds 31
Sub-petiolar buds 25
Subulate leaf 141
Suckers 36, 39
Sugar Cane 84
Sumach 211
Superficial periderm 94, 96, 98
Superposed buds 26, 30, 34, 36, 37
Suppressed buds 23, 29
Surface of bud-scales 27
Surface characters of twigs 99, 107, 124
Sweet Briar 202
Sweet Gale 33, 53, 110, 111, 116, 117, 125, 234
Swelling of bud 64
Swiss Pine 134
Sycamore 29, 30, 53, 54, 57, 59, 63, 68, 109, 111, 112, 114, 115, 117, 118, 155, 156
Symphoricarpos 30, 37, 53, 108, 109, 110, 116, 117, 119
S. racemosa 33, 173
Sympodia 113, 115
Syringa 115, 123
Syringa 37
S. vulgaris 157

T-shaped hairs 89, 90
Tamarisk 63, 110, 111, 116, 121, 123, 142, 206
Tamarix gallica 206
Tawny twigs 109
Taxus baccata 138
Tea-leaved Willow 253
Tegumentary system 81, 94
Tendril 43, 124, 162
Tendril-climbers 124, 129, 162
Tentacles 92
Terminal buds 6, 7, 13, 23, 28, 30, 64, 68, 114, 133, 137, 159
Texture of bud-scales 14, 16, 27
Theoretical diagrams 41, 46, 48
Thorns 76, 80, 92, 113, 122, 124, 127, 128, 159, 189
Three-needled pines 134
Three-ranked buds 32
Thrusts of expanding leaves 64, 65
Thuja 63
T. gigantea 142
Tilia 48, 177
T. europæa 186
T. grandifolia 187
T. parviflora 187
Tomentose hairs 88, 126
Tradescantia 90
Transition of scales to leaves 9, 16
Transition of shoots 76, 79
Transitional arrangements of bud-scales 49, 55, 58
Transitional bud-scales 16, 27, 49, 50
Transverse sections of buds 41, 45
Traveller's Joy 162
Tree of Heaven 211
Trichome 92
Tufted hairs 90
Tulip Tree 60
Turkey Oak 117, 216
Twigs 3, 7, 8, 64, 71, 107
Twining plants 124, 129, 162
Two-needled Pines 134
Two-ranked buds 32

U-shaped leaf-scars 117
Ulex europæus 145, 190
U. nanus 145, 190
Ulmus 25, 27
U. campestris 109, 180, 181, 182, 184
U. effusa 180, 182, 184
U. montana 182, 183, 184
U. suberosa 180
Unarmed plants 147, 150
Unicellular hairs 86, 88
Urtica 90
Urticaceæ 91
Utricularia 92

V-shaped leaf-scars 117
Variations in development of shoots 76
Variations in growth 64, 73
Vascular tissues 102
Velvety hairs 86, 88, 90, 126
Venation 100
Verbascum 88, 90
Vertical sections of bud 64, 65
Verticels 31
Vesicular hairs 91
Vessels 100, 102
Viburnum 59, 118
V. Lantana 27, 50, 70, 96, 165

V. nudum 27
V. Opulus 95, 167, 168
Villose hairs 86, 88, 90
Vine 5, 23, 42, 43, 53, 55, 57, 59, 60, 96, 99, 109, 117, 118, 119, 121, 123, 129, 130, 188, 189
Viola tricolor 92
Violet twigs 112
Virginian Creeper 59, 119, 123, 129, 130
Viscid buds 15, 16, 149, 150, 219
Viscid hairs 91
Viscum album 142
Vitis 43, 188

Walnut 23, 25, 33, 52, 53, 55, 59, 61, 69, 70, 96, 108, 109, 110, 112, 114, 116, 117, 118, 119, 121, 122, 211
Water Lily 85
Water supply 100, 101
Wax 81, 83, 124
Wayfaring Tree 15, 30, 63, 70, 109, 110, 114, 115, 117, 119, 122, 127, 165
Weymouth Pine 134
Whin 116
White Beam 236, 237, 238
White Mulberry 111, 112
White Poplar 39, 61, 89, 109, 111, 114, 117, 119, 126, 227, 228
White twigs 108
White Willow 109, 126, 252, 253
Whitethorn 194
Whorled bud-scales 49, 54
Whorled leaves 58
Whorls 30, 31, 34, 58, 141
Wild Cherry 69
Wild Plum 242, 243
Willow 24, 25, 29, 33, 40, 53, 55, 56, 58, 59, 63, 68, 80, 93, 96, 112, 114, 116, 117, 118, 119, 121, 123, 168, 247
Wind-distributing hairs 93
Winter buds 9, 15, 27
Winter state 64, 68, 75
Winter twigs 7, 106
Woodbine 163
Woolly hairs 86, 88, 90, 126
Wrinkled surface 127
Wych Elm 126, 182, 183

Y-shaped leaf-scars 117
Yellow twigs 109
Yew 51, 63, 68, 94, 96, 99, 108, 111, 116, 138
Yucca 83

Zelkova 37

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